

INCREASING U.S. SCIENTIFIC MANPOWER

HEARING
BEFORE THE
SUBCOMMITTEE ON
SCIENCE, RESEARCH AND TECHNOLOGY
OF THE
COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
ONE HUNDRED FIRST CONGRESS
SECOND SESSION

JULY 31, 1990

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INCREASING U.S. SCIENTIFIC MANPOWER

TUESDAY, JULY 31, 1990

U.S. HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:30 a.m., in room 2318 Rayburn House Office Building, Hon. George E. Brown, Jr. [acting chairman of the subcommittee] presiding.

Mr. BROWN. The subcommittee will come to order.

I am going to make an opening statement while we continue to look for a few more members and hope that we can round up some.

Today we are examining the effects of immigration law, policies, and trends on scientific manpower. In particular, we will focus on proposed changes in U.S. immigration law, on the emigration from the U.S. on foreign born naturalized U.S. scientists and engineers, and on the efforts of newly arrived refugee scientists to find employment that matches their skills and qualifications.

We have assembled a very distinguished and talented group of witnesses and we look forward to their testimonies.

Many key roles in America's rapid development from a rural, agrarian-based country to an industrial, technological super power have been played by immigrants. Each generation of Americans has been blessed by highly talented immigrants who have blossomed in this country. The Carnegies, DuPonts, Sarnoffs, and Wangs left major companies as their legacies. Our most famous scientific geniuses—such as Einstein, Tesla, Fermi, and Steinmetz—were born and raised overseas.

In recent years, the number of immigrant scientific personnel in the U.S. workforce and the foreign graduate students in science and engineering in U.S. colleges and universities have markedly increased. At the same time, American students have been turning away from careers in science and engineering in both industry and academia for other, perhaps more lucrative pursuits. Today, American industry, academia, and even the U.S. Government rely heavily on the talents provided by foreign-trained personnel to make up for the shortages resulting from the smaller numbers of native born Americans choosing science and engineering as a career. This dependence on immigrant scientists is expected to continue unabated for some time.

Hiring foreign scientists, both as permanent and non-permanent immigrants, under current U.S. immigration law can be a time consuming and lengthy process, often taking more than just one year, sometimes as long as five years. In contrast, a German scien-

tist can be hired in another European country within a matter of days. Given today's increasingly international competition for scientific and technical talent, it comes as no surprise that American industry and academia have great concerns for our current immigration system and with pending legislation that would alter those laws with respect to admission of scientific personnel.

Together with immigration, we are also eager to learn about the emigration of foreign born naturalized U.S. scientists and engineers. Certain foreign governments, especially in the Pacific Rim, are actively encouraging their nationals living and working in the U.S. to repatriate. Simultaneously, American multinational companies are moving more of their research and development abroad, opening up opportunities outside this country for U.S.-trained, foreign born scientists and engineers.

Immigration is an important issue not to be overlooked when considering how immigration affects the quantity of scientific personnel available in the U.S.

The third issue we will look at today involves the success or failure that newly arrived refugee scientists and engineers have had in finding professional employment. Is a Soviet Ph.D. chemist or mathematician likely to be qualified for a position in an American university or company which has an opening in his area of expertise? Does a refugee computer scientist need retraining before he can apply his talents in American industry? When scientists and engineers must accept jobs which do not require their skills and knowledge in order to make ends meet, have we done the refugees a favor by bringing them to the U.S.? Are we hurting this country when sizable numbers of individuals work at jobs well beneath their potential?

I might say that at the same time this hearing is going on there is a similar hearing going on with regard to one of the two immigration bills which relates to this matter—H.R. 4300, which was authored by Congressman Morrison dealing with this subject. So we expect that there may be some action from the Congress either in this session or possibly in the next session.

[The prepared opening statements of Representatives Brown, Morella and Costello follow:]

OPENING STATEMENT OF
THE HONORABLE GEORGE E. BROWN, JR. (D-CA)
ON
INCREASING U.S. SCIENTIFIC MANPOWER

July 31, 1990

Today, we are examining the effect of immigration law, policy and trends on scientific manpower. In particular, we will focus on proposed changes in U.S. immigration law, on the emigration from the U.S. of foreign-born, naturalized U.S. scientists and engineers, and on the efforts of newly arrived refugee scientists to find employment that matches their skills and qualifications. We have assembled a distinguished and talented group of witnesses and we look forward to their testimony.

Many key roles in America's rapid development from a rural agrarian-based country to an industrial, technological superpower have been played by immigrants. Each generation of Americans has been blessed by highly talented immigrants who have blossomed in this country. The Carnegies, DuPonts, Sarnoffs, and Wangs left major

companies as their legacies. Our most famous scientific geniuses, such as Einstein, Tesla, Fermi, and Steinmetz, were born and raised overseas.

In recent years, the numbers of immigrant scientific personnel in the U.S. work force and of foreign graduate students in science and engineering in U.S. colleges and universities have markedly increased. At the same time, American students have been turning away from careers in science and engineering, in both industry and academia, for other, perhaps more lucrative pursuits. Today, American industry, academia and even the U.S. Government rely heavily on the talents provided by foreign trained personnel to make up for the shortages resulting from the smaller numbers of native born Americans choosing science and engineering as a career. This dependence on immigrant scientists is expected to continue unabated for some time.

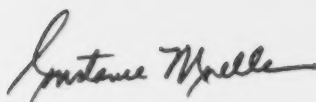
Hiring foreign scientists, both as permanent and

non-permanent immigrants, under current U.S. immigration law, can be a time-consuming and lengthy process, often taking more than just one year, sometimes as long as five years. In contrast, a German scientist can be hired in another European country within a matter of days. Given today's increasingly international competition for scientific and technical talent, it comes as no surprise that American industry and academia have great concerns for our current immigration system, and with pending legislation that would alter those laws, with respect to the admission of scientific personnel.

Together with immigration, we are also eager to learn about the emigration of foreign-born naturalized U.S. scientists and engineers. Certain foreign governments, especially in the Pacific Rim are actively encouraging their nationals living and working in the U.S. to repatriate. Simultaneously, American multi-national companies are moving more of their research and development abroad, opening up opportunities outside this country for

U.S.-trained foreign born scientists and engineers. Emigration is an important issue not to be overlooked when considering how immigration affects the quantity of scientific personnel available in the U.S.

The third issue we will look at today involves the success or failure that newly arrived refugee scientists and engineers have had in finding professional employment. Is a Soviet Ph.D. chemist or mathematician likely to be qualified for a position in an American university or company which has an opening in his area of expertise? Does a refugee computer scientist need retraining before he can apply his talents in American industry? When scientists and engineers must accept jobs which do not require their skills and knowledge in order to make ends meet, have we done the refugees a favor by bringing them to the U.S.? Are we hurting this country when sizeable numbers of individuals work at jobs well beneath their potential?



STATEMENT BEFORE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY

JULY 31, 1990

INCREASING U.S. SCIENTIFIC MANPOWER

Thank you Mr. Chairman. Today we meet to evaluate United States dependence on immigrants in scientific and engineering-related fields. Current immigration law is not built towards attracting scientists and engineers, but rather favors family reunification. Under the current preference system, only 10% of the worldwide ceiling of 270,000 legal immigrants given visas from the U.S. each year are designated to be "persons of exceptional ability in the sciences and arts." Refugees, and relatives of U.S. citizens are exempt from this numerical quota--in 1988 over 375,000 immigrants were admitted under this exemption. As yet, there is no general consensus as to what would be the ideal composition of immigration to the U.S. each year.

Despite the limits on the immigration of scientists, there are many foreign science and engineering graduate students here on temporary visas. In 1987, this number reached 60,000. However, there is a trend among these people to return to their native lands after completing their studies. Do the current immigration laws impede these scientists from obtaining visas, thus giving them no choice than to return to their country? We must evaluate the reasons behind these scientists' emigration. After the years spent, and resources invested to educate these foreign students, our nation could benefit from the knowledge that they possess. Currently in the U.S., there exists a shortage of educators in the math and science fields. As the United

States is moving forward in technology, there lies a need for educators to move this along--and these foreign scientists possess the ability to do this.

The immigration of scientists, though reciprocal in its providing for the national interest in exchange for opportunities for foreign scientists, should not move forward without consideration to scientists currently citizens of the U.S. Though the U.S. can benefit from the resources of these foreign scientists, the jobs of U.S. scientists should be considered, and not put in jeopardy. Ideally, the U.S. immigration system should be flexible and responsive to the labor shortage in scientific fields without taking jobs away from worthy U.S. scientists. H.R. 4300 and S. 358, the subject of our discussion today, both aim to increase the number of visas available to foreign scientists to 95,000 and 150,000 respectively in order to increase U.S. scientific manpower. I look forward to hearing from our panelists.

OPENING STATEMENT

BY U.S. REP. JERRY F. COSTELLO, ILLINOIS

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

HEARING ON INCREASING U.S. SCIENTIFIC MANPOWER

JULY 31, 1990

Mr. Chairman, this hearing will focus on whether existing immigration law impedes the ability of the U.S. to attract foreign scientists and engineers. We have all heard a great deal about the sorry state of science education in our country, and we have heard a great deal about a new commitment to change this situation.

The United States is facing an extremely competitive international marketplace, and science and technology is one area in which we have lost ground. Because our national security and our standard of living depend upon our leadership in this area, we must make sure that our immigration laws do not prevent immigrants from filling important vacancies.

I wish to thank our witnesses for sharing their insight with us today and I would like to thank you, Mr. Chairman, for convening this hearing.

Mr. BROWN. This morning we are fortunate in having a very distinguished group. Our first panel will represent the National Science Foundation and the National Institutes of Health, as well as representing Duke University. Doctor Karl Willenbrock is the Assistant Director Scientific, Technological, and International Affairs at the National Science Foundation, and he is accompanied by Charles Herz, the General Counsel. Doctor Philip Schambra is the Director of the Fogarty International Center at the National Institutes of Health. And in addition we have Doctor Phillip Griffiths, who is Provost and James B. Duke Professor of Mathematics at Duke University.

Are we all here? Looks like we are.

It is a pleasure to see you all here this morning. We look forward to your testimony.

You may start, Doctor Willenbrock.

STATEMENT OF DR. F. KARL WILLENBROCK, ASSISTANT DIRECTOR FOR SCIENTIFIC, TECHNOLOGICAL, AND INTERNATIONAL AFFAIRS, NATIONAL SCIENCE FOUNDATION; ACCOMPANIED BY: CHARLES H. HERZ, GENERAL COUNSEL

Dr. WILLENBROCK. Thank you very much, Mr. Chairman. I am pleased to appear before you today.

One of the most important issues facing this nation is the availability of a high quality technical work force. An adequate supply of highly educated scientists and engineers is critical to our economic competitiveness. Our first responsibility as a nation is to increase the numbers of Americans obtaining degrees in science and engineering.

However, immigration has, historically, also made significant contributions to our technical talent pool and will continue to do so. By the end of the century, we will be competing with other industrialized nations for a shrinking pool of talent.

In today's global economy, capital and technology easily cross international boundaries and flow to where the human talent is. To compete effectively, the U.S. needs an increase in the number and quality of scientists and engineers. We face many obstacles to achieving this goal:

- The college age population in the United States is expected to decline from the 30 million it was in 1982 to 24 million in 1995;
- During this time, the percent of young people from minority groups will increase from 20% to 27%.

Increasingly, women and minorities will constitute a larger percentage of our workforce, and these groups, historically, have had low rates of participation in the sciences and engineering.

If current trends continue, by the end of the century we will not have enough scientists and engineers to satisfy the needs of our universities, industry, and Government. Nor will other nations.

As a group, 29 industrialized and newly industrializing countries which are the major producers of science and engineering degrees will experience a decline in college age people.

Approximately half of the full time students in graduate engineering programs in the U.S. are not U.S. citizens, and several of the other disciplines—like mathematics and physics—are not far

behind. About half of these students remain in the U.S. when they graduate. They contribute to our industries, to our universities, and to our economy and we have grown increasingly dependent on them.

In 1982, 17 percent of employed scientists and engineers were foreign born compared to 9.6 percent in 1972.

From 1980 to 1988, the number of foreign science and engineering post doctoral fellows working in the U.S. universities increased from 5 thousand to 9 thousand.

Persons born abroad account for

- 32 percent of U.S. citizens awarded Nobel Prizes for scientific achievements since 1945;
- 23 percent of the members of the National Academy of Sciences and 18 percent of the members of the National Academy of Engineering are foreign born;
- 50 percent of U.S. assistant professors of engineering younger than age 35 are foreign born.

But this situation may not last. Countries like Taiwan and Korea have programs to repatriate their science and engineering nationals from the U.S., offering them financial inducements, including cash incentives for repatriation, air fares, and other benefits.

A decline in immigration of scientists and engineers has already begun. The INS reports that the small number of scientists and engineers who immigrated to the U.S. has actually declined from 13,300 in 1970 to 10,900 in 1988. Scientists and engineers constitute 3.6 percent of immigrants admitted in 1970, compared to 1.7 percent of those admitted in 1988.

Most immigrants come in under family preferences, but scientists and engineers only constitute 1 percent of those admitted under this provision. In contrast, they constitute 30 percent of those admitted under the preference which is reserved for skilled workers.

Mr. Chairman, you also asked us to report on the number of foreign born scientists and engineers who leave the United States. Unfortunately, no agency of the Federal Government maintains a count; we can only give rough estimates.

A recent study sponsored by the National Science Foundation found that among foreign born engineering and computer science Ph.D.s living in the U.S. in 1981, 1.3 percent of those who became U.S. citizens left by 1985. In contrast, 13.8 percent of those who had green cards, and 45 percent of those who were on temporary visas left by that year.

Each year about 18,000 scientists and engineers also enter into the U.S. on temporary visas. In 1988, 27 percent of the U.S. engineering Masters degrees and 44 percent of the Ph.D.s went to foreigners here on temporary visas. Of these, 62 percent of the Bachelors and Masters and 50 percent of the Ph.D.s nevertheless remained here to work.

In today's global economy, excluding immigrant scientists and engineers will not protect the jobs of U.S. workers. The Nation already has the benefit of a technologically advanced economy. But retaining that advantage depends on keeping and increasing the pool of trained technical people.

Mr. Chairman, there are many indications of the need to increase the quantity and quality of scientists and engineers working in the U.S. We see immigration as a part of an integrated approach to insuring the availability of the high quality technical workforce we need in both the short and long term. It complements our efforts to increase the participation of Americans in the sciences and engineering.

Thank you, Mr. Chairman. That concludes my formal statement; a more complete statement will be submitted to the record with your permission.

[The prepared statement of Dr. Willenbrock follows:]

NATIONAL SCIENCE FOUNDATION
STATEMENT OF
DR. KARL WILLENBROCK
ASSISTANT DIRECTOR
FOR
SCIENTIFIC, TECHNOLOGICAL, AND INTERNATIONAL AFFAIRS
BEFORE THE
HOUSE SCIENCE, SPACE, AND TECHNOLOGY COMMITTEE
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES
JULY 31, 1990

Mr. Chairman, I am pleased to appear before you today. This subcommittee is to be commended for holding a hearing on increasing U.S. science and engineering manpower and on the relationship of immigration to this objective.

One of the most important issues facing this nation is the availability of a high quality technical work force. An adequate supply of highly educated scientists and engineers is critical to our economic competitiveness. Our first responsibility, as a Nation, is to increase the numbers of Americans obtaining degrees in the sciences and engineering.

The President's budget for FY 1991 includes an increase in funds to support the education of more U.S. scientists and engineers. NSF is committed to a vigorous program that we believe will meet the challenge of providing America with the scientists and engineers it needs.

However, immigration has, historically, also made significant contributions to our technical talent pool and will continue to do so. By the end of the century, we will be competing with other industrialized nations for a shrinking pool of talent.

In today's global economy, capital and technology easily cross international boundaries and flow to where the human talent is. To compete effectively, the U.S. needs an increase in the number and quality of scientists and engineers. We face many obstacles to achieving this goal:

o The college age population is expected to decline from the 30 million it was in 1982 to 24 million in 1995;

o During this time, the percent of young people from minority groups will increase from 20% to 27%.

Increasingly, women and minorities will constitute a larger percentage of our work force, and these groups, historically, have low rates of participation in the sciences and engineering. To increase the number of scientists and engineers we will have to breakdown the historic barriers that have channeled women and minorities away from technical careers.

If current trends continue, by the end of the century, we will not have enough scientists and engineers to satisfy the needs of our universities, industry, and government. Nor will other nations.

As a group, 29 industrialized and newly industrializing countries which are the major producers of S&E degrees will experience a decline in college age people. Many of these are the very countries which in the past have sent science and engineering graduates with baccalaureate degrees to the U.S. for graduate education.

Approximately half of the full time students in graduate engineering programs in the US are not U.S. citizens, and several of the other disciplines, like mathematics and physics, are not far behind. Foreign students are among the most intellectually able students we have, and they provide an important global perspective to the educational process at our universities. About half of these students remain in the US when they graduate. They contribute to our industries, to our universities, and to our economy and we have grown increasingly dependent on them.

* In 1982, 17% of employed scientists and engineers were foreign born compared to 9.6% in 1972.

* From 1980 to 1988, the number of foreign science and engineering post doctoral fellows working in US universities increased from 5 thousand to 9 thousand.

Recently, the National Academy of Sciences consulted the R&D directors of 20 major high tech companies who said they are "dependent upon foreign talent and that such dependency is growing." Persons born abroad account for:

* 32 percent of US citizens awarded Nobel prizes for scientific achievements since 1945;

* 23 percent of the members of the NAS, and 18 percent of the members of the National Academy of Engineering;

- * 20 percent of our science and engineering university faculty; and
- * 50 percent of U.S. assistant professors of engineering younger than age 35.
- * Currently, 20 percent of the faculty working at 400 US engineering departments earned their Bachelors degrees abroad.

Between 1981 and 1985, 700 foreign engineering and computer students emigrated on the completion of their doctorates. However, in the same period, 4000 new foreign PhD recipients stayed in the US to work, for a net gain of 3300, or 37% of the growth in the US engineering and computer science PHD workforce.

But, this situation may not last. In some countries like Taiwan and Korea have programs to repatriate their S&E nationals from the US, offering them financial inducements, including cash incentives for repatriation, air fares, and other benefits.

A decline in immigration of scientists and engineers has already begun:

- * In the last 20 years, science and engineering employment in the United States more than doubled.
- * Total immigration grew from close to 400 thousand to nearly 700 thousand.
- * However, the INS reports that the small number of scientists and engineers who immigrated to the US has actually declined from 13,300 in 1970 to 10,900 in 1988.
- * Scientists and engineers constituted 3.6% of immigrants admitted in 1970, compared to 1.7% of those admitted in 1988.

Under current law, most immigrants come in under family preferences. But scientists and engineers only constitute 1% of those admitted under this provision. In contrast, they constitute 30% of those admitted under the preference which is reserved for skilled workers.

Mr. Chairman, you also asked us to report on the number of foreign born scientists and engineers who leave the U.S.. Unfortunately, no agency of the federal government maintains a count; we can only give rough estimates. The visa status of entering scientists and engineers is a powerful predictor of whether or not they will stay. Immigrants tend to stay. Those who do not have green cards are more likely to return home.

A recent study sponsored by NSF patched together all of the pieces of information we have on immigration and emigration of scientists and engineers from 1981 to 1985. That study found that among foreign born engineering and computer science PhDs living in the US in 1981, 1.3% of those who had become U.S. citizens left by 1985. In contrast, 13.8% of those who had green cards, and 45% of those here on temporary visas left by that year.

Many of those here on temporary visas do succeed in remaining in the US to work. Each year about 18,000 S&E also entered the US on temporary visas. In 1988, 27% of the US engineering Masters degrees and 44% of the PhDs went to foreigners here on temporary visas. Of these 62% of the Bachelors and Masters and 50% of the PhDs nevertheless remained here to work.

We estimate that up to 30 percent of science and engineering immigrants leave the United States and continue their careers abroad. Experience shows that about 85% of those who stay in the United States apply for and take U.S. citizenship.

In today's global economy, excluding immigrant scientists and engineers will not protect the jobs of U.S. workers. The Nation already has the benefits of a technologically advanced economy. But retaining that advantage depends on keeping and increasing the pool of trained technical people.

One situation can be addressed directly. Foreigners make up about a third of the post docs at US government laboratories, but virtually all of them are on J-1 visas, which require them to leave the United States upon completion of their work.

Mr. Chairman, there are many indications of the need to increase the quantity and quality of scientists and engineers working in the US. We see immigration as a part of an integrated approach to insuring the availability of the high quality technical workforce we need in both the short and the long term. It complements our efforts to increase the participation of Americans in the sciences and engineering and provides access to some of the best talent on a global basis.

Thank you, Mr. Chairman. That concludes my testimony.

Mr. BROWN. Thank you very much Doctor Willenbrock.

May I ask our other members if they would care to make a statement at this time or insert one in the record?

Mr. BOEHLERT. Mr. Chairman, I would like to get moving, but I do ask that my statement appear in the record.

Mr. BROWN. Without objection, so ordered.

[The prepared opening statement of Mr. Boehlert follows:]

Jimmy S. Butler

Mr. Chairman:

I just want to take a moment to stress the importance of this morning's subject.

Immigration issues are often framed in terms of impending shortages of scientists and engineers. The debate then often devolves into a discussion of the likelihood of such shortages -- an extremely speculative game.

But there is another reason to want to attract and retain as many foreign scientists and engineers as possible. Our nation's success in science and engineering -- and in more general ways, as well -- rests largely on our ability to use the entire world as our talent pool. The capacity of this nation to serve as a safe haven, politically and economically, for foreigners has saved us more than once -- the Manhattan Project being the most obvious example.

In our current race for economic success, our ability to tap foreign talent is more important than ever. Our competitors have more financial capital to bring to bear on the problem; our advantage is in human capital. This is especially a "leg up" on the Japanese and the Germans -- two of the most xenophobic societies on Earth. They recognize our advantage in this area, and try to buy

research overseas to compensate.

We need to acknowledge our dependence on immigrants for our past and future successes as we listen to today's witnesses. Thank you.

Mr. BROWN. Ms. Schneider?

Ms. SCHNEIDER. Mr. Chairman, I would also ask that my statement be included in the record.

Let me say that I am delighted that the National Science Foundation is so ably represented here by Doctor Willenbrock. I think that the NSF is our constant guardian in keeping us aware of the problems. I think that more often than not many of us are frustrated in seeking appropriate solutions. So we hope that after we hear the testimony of the other witnesses, we may proceed a little further to try to come up with some more appropriate answers to the dilemma that you have shared with us.

Thank you very much, Mr. Chairman.

Mr. BROWN. Thank you, Ms. Schneider.

Doctor Schambra, do you wish to proceed?

STATEMENT OF DR. PHILIP SCHAMBRA, DIRECTOR, FOGARTY INTERNATIONAL CENTER, NATIONAL INSTITUTES OF HEALTH, BETHESDA, MARYLAND

Dr. SCHAMBRA. Thank you, Mr. Chairman.

Mr. Chairman and members of the subcommittee, we at NIH appreciate this invitation to testify at this timely hearing on the growing shortage of scientific manpower, and the role of U.S. immigration policy in impacting on the future supply of well-trained researchers.

I would like to submit my complete statement for the record, if I may, and present a summary of my remarks.

Mr. BROWN. Without objection, so ordered.

Mr. SCHAMBRA. Thank you, Mr. Chairman.

Mr. Chairman, the impending shortage of scientific manpower is perhaps one of the most serious problems facing NIH and the biomedical research community in the 1990s. How we deal with this issue will to a large degree determine the pace of research progress on AIDs, cancer therapeutics, and other public health priorities; in addition to significant initiatives such as biotechnology and the human genome project.

The NIH provides the base of support for around 50,000 scientists at universities and other research institutes and an equal number of support personnel. In addition, the laboratories of NIH institutes are staffed by some 5,000 scientists, one third of whom are researchers from abroad.

A sampling of the major university recipients of NIH support indicates that the percentage of foreign nationals among university research staff is also substantial at both the predoctoral and postdoctoral levels.

Besides playing a significant role in academic research, these scientists constitute a large educational investment, since one-quarter of the 40,000 graduate students in biological sciences are foreign nationals.

Our ability to recruit, and of equal importance, to retain an excellent scientific workforce is of increasing concern due to the present and impending shortages of research manpower. This subcommittee has heard testimony in the past year from a number of organizations regarding the supply and demand of scientific per-

sonnel. Although the models used to predict these shortfalls diverge in their quantitative findings, their conclusions are fundamentally the same— unless corrective action is taken in the immediate future, universities, industry, and Government will begin to experience shortages of scientists in the next four to six years, with the shortage persisting well into the next century.

This predicament is largely the result of a sharp demographic downturn in the college-aged population, which before the end of the decade is expected to decline by more than 25 percent from the 1985 level. It is unlikely that the percentage of students who are awarded baccalaureate and doctorate degrees in scientific fields will increase rapidly enough to compensate for this decline.

In the biological sciences, the National Academy of Sciences estimates that to maintain the 1985 level of research trainees into the 1990s, the degree award rate would have to increase by 30 percent. Unfortunately, the number of baccalaureate degrees awarded in the biological sciences has been steadily declining since 1977.

NIH is now experiencing an early manifestation of an inadequate manpower pipeline. There has been a persistent decline in the number of younger applicants for NIH extra mural grant awards over the past decade.

At the same time that the pool of trained manpower in the biological sciences decreases, the demand in academia and industry is expected to rise significantly. This is due to the need of academic institutions to replace retiring research and teaching faculty and to the growing demand in industry resulting from rapid advances in biotechnology. Based on demographic and economic trends, the Bureau of Labor Statistics forecasts a 26 percent increase in the number of new jobs for biological scientists by the end of this decade.

Thus, the NIH shares the challenge with our sister science agencies of attracting dramatically more students into our research career from a decreasing manpower supply. We face significant impediments: recruitment and retention strategies to increase the educational pipeline will not be felt for at least a decade. Further, expanding the resource base for training and education to required levels will prove difficult in this era of deficit spending and competing national priorities.

Given these constraints on human resource development, NIH is encouraged that Congress is turning its attention to immigration reform, which increase opportunities for prospective new entrants with desired professional skills.

In my written testimony, I have addressed two issues which may help support your deliberations on current and future immigration legislation. First, how important to our national research health programs is the foreign scientists workforce, both temporary workers and immigrant scientists? And second, do present immigration laws serve the interests of these programs?

The contribution of foreign scientists to the NIH research programs has been substantial. A recent survey of the most productive of NIH's laboratories reveal that an average of 46 percent of the scientific publications from those laboratories are co-authored by foreign researchers. Notable advances in our understanding of cancer and immunology, including the identification of the AIDS

virus, benefitted from the contributions of visiting researchers from abroad.

Because of limited opportunities in their home countries, many foreign scientists have successfully petitioned to continue their careers in the U.S.; some have gone on to the elected to the National Academy of Sciences and have even been awarded the Nobel Prize.

Because of the fact that the demand for scientific and technical personnel is unlikely to be satisfied by domestic sources, international opportunities to increase our Nation's human resources become even more important.

Mr. Chairman, I believe that without impeding the humanitarian intent of our current policy, we can improve this Nation's competitiveness and accelerate advances in scientific research through selective reforms in our immigration policy. Adoption of a more skilled-based immigration policy for professionals whose skills are in short supply would improve the ability of Government, academia, and industry to meet their manpower needs. Improvements could be made in regard to:

- First of all, restrictions on the number of permanent resident visas available for skilled workers in short supply;
- Second, the current labor certification system; and
- Third, the administration of the present non-immigrant temporary worker, the H-1, and the exchange visitor, the J-1, visa categories.

Mr. Chairman, thank you for this opportunity to address these important issues. In closing, I would like to emphasize that NIH is the destination for researchers worldwide to find a cure for the AIDS epidemic, cancer, heart disease, and other public health challenges. The great limiting factor which faces us in this critical biomedical enterprise is the human one. We are hopeful that in an increasingly competitive world Congress will enact legislation which will enable this Nation to improve its ability to recruit and retain highly qualified scientists from around the globe.

This concludes my prepared statement, Mr. Chairman. I would be pleased to respond to any questions that you or other members of the subcommittee may have.

[The prepared statement of Dr. Schambra follows:]

STATEMENT

BY

PHILIP E. SCHAMBRA, PH.D.

DIRECTOR

FOGARTY INTERNATIONAL CENTER
NATIONAL INSTITUTES OF HEALTH

BEFORE THE

SCIENCE, SPACE AND TECHNOLOGY
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

JULY 31, 1990

Introduction

Mr. Chairman and Members of the Subcommittee:

I am Dr. Philip Schambra, Director of the Fogarty International Center at the National Institutes of Health (NIH). Thank you for your invitation to testify at this timely hearing on the growing shortage of scientific manpower, and the possible role of U.S. immigration policy as a means of ensuring the future supply of well-trained researchers. The impending shortage of scientific manpower is perhaps one of the most serious problems facing NIH and the biomedical research community in the 1990's. How we deal with this issue will to a large degree determine the pace of research progress on AIDS, cancer therapeutics and other public health priorities, in addition to significant initiatives such as biotechnology and the human genome project.

The NIH is responsible for over one-third of the nation's total expenditures on health research and an estimated 90% of its basic biomedical and behavioral research. We provide the base of support for around 50,000 scientists at universities and other research institutes and an equal number of support personnel. In addition, the laboratories of NIH institutes are staffed by some 5,000 scientists, one third of whom are researchers from abroad under a variety of international

scientific programs mandated by the Public Health Service Act of 1944 and the Fulbright-Hays Act of 1961. A sampling of the major university recipients of NIH support indicates that the percentage of foreign nationals among university research staff is also substantial at both the predoctoral and postdoctoral levels. Besides representing a significant role in academic research, these scientists constitute a large educational investment, since one-quarter of the 40,000 graduate students in the biological sciences are foreign nationals.

Our ability to recruit, and of equal importance, to retain an excellent scientific workforce is of increasing concern due to present and impending shortages of research manpower. This Subcommittee has heard testimony in the past year from a number of organizations regarding the supply and demand of scientists and engineers. Although the models used to predict these shortfalls diverge in their quantitative findings, their conclusions are fundamentally the same. Dr. Richard Atkinson, President of the American Association for the Advancement of Science (AAAS), who has served as a witness to this Subcommittee, reviewed various supply/demand projections at the annual meeting of the AAAS last February. He concluded that unless corrective action is taken in the immediate future, universities, industry and government will begin to experience shortages of scientists and engineers in the next 4 to 6 years, with the shortage persisting well into the next century.

Assuming a stable economic growth rate, Dr. Atkinson anticipates a cumulative supply/demand gap of several hundred thousand Ph.D. scientists and engineers by the end of the next decade.

The Impending Shortage of Scientists

This predicament is largely the result of a sharp demographic downturn in the college-aged population, which is expected to decline by more than 25% percent before the end of the decade. It is unlikely that the percentage of students who are awarded baccalaureate and doctoral degrees in science and engineering will increase rapidly enough to compensate for this decline. In the biological sciences, the National Academy of Sciences estimates that to maintain the 1985 level of research trainees into the 1990's, the degree award rate would have to increase by 30%. Unfortunately, the number of baccalaureate degrees awarded in the biological sciences has been steadily decreasing since 1977.

As the available pool of trained manpower in the biological sciences decreases, the demand in academia and industry is expected to rise significantly. Because of the age-distribution of the Ph.D. workforce, the replacement demand for scientists and engineers will double by the year 2010. This trend will have a considerable impact on our universities,

since large numbers of faculty hired during the baby boom of the 1960's will begin to retire towards the end of the decade. At the same time, there will be growing demand in industry for biological scientists, largely attributable to the expanding product development opportunities resulting from advances in biotechnology. The industrial sector has now in fact overtaken NIH as the leading source of health research expenditure in the U.S. NIH is already experiencing a significant migration of its scientific staff to industry. Based on demographic and economic trends, the Bureau of Labor Statistics forecasts a 26% increase in the number of new jobs for biological scientists by the end of this decade.

Thus, NIH shares the challenge with our sister science agencies of attracting dramatically more students into a research career from a decreasing manpower supply. Potential recruitment and retention strategies which have been advocated include increased fellowship support to raise the baccalaureate and doctoral conferral rates in science and engineering: during the last 20 years, the number of federally supported graduate fellowships and traineeships decreased from about 60,000 to fewer than 14,000. Special emphasis is being placed on drawing women and minorities into science, who along with immigrants will constitute 85% of the new entrants to the workforce by the middle of this decade. In addition, measures have been advocated to augment federal support for science and

mathematics faculty training and curricula development in the nation's primary and secondary schools, so that we may ensure a sufficient number of future scientists for the myriad opportunities which science and technology will present in the next century.

In efforts to attract more students into research careers, NIH has reassessed and revised its National Research Service Awards and Research Career Programs. Similar initiatives are underway at NSF through the Career Access Program. This Subcommittee has played a pivotal role in focusing national attention on problems in recruitment and retention of U.S. students in science and engineering programs and other problems in the educational pipeline. However, we face significant impediments. Most current and proposed federal actions to increase the supply of scientists and engineers will not be felt for at least a decade. Further, expanding the resource base for training and education to required levels will prove difficult in this era of deficit spending and competing national priorities.

Given these constraints on human resource development, NIH is encouraged that Congress is turning its attention to immigration reforms which increase opportunities for prospective new entrants with desired professional skills. We are following the progress of immigration bills now under

consideration by the House and Senate with great interest. The number and quality of scientists and engineers is a prime determinant of a nation's ability to function in global competition. I firmly believe that Congressional action taken on immigration reform will have a profound effect on our ability to maintain global leadership in science and technology in the 21st century.

This morning, I would like to address two issues which may help support your deliberations on current and future immigration legislation. First, how important to our national health research programs is the international pipeline of foreign scientists, both temporary workers and immigrant scientists? Do they fulfill a human resource need that cannot be met through domestic sources? And second, do present immigration laws serve the interests of these programs?

Contribution of the Foreign Workforce

NIH has the largest representation of foreign nationals among federal laboratories, followed by the Department of Energy. Thirty-four percent of the foreign research manpower pool employed by federal agencies work at NIH under the various foreign scientist programs, administered by the Fogarty International Center. Since their inception, these programs have contributed significantly to many of the major research

advances at NIH. In the most productive of NIH's laboratories, an average of 46% of the scientific publications are co-authored by visiting researchers. In some of the more prominent laboratories such as those of Dr. Robert Gallo and Nobel Laureates Carleton Gajdusek and Marshall Nirenberg, this figure is much higher. Prominent laboratories such as these have served as powerful magnets for an international cadre of highly talented young researchers.

Research advances in which visiting foreign scientists at NIH have made significant contributions include the characterization of tumor-promoting genes causing many types of malignancies; this information will be very valuable in the diagnosis, expected prognosis and treatment of human cancers. Vaccines against rotaviruses, hepatitis B and other infectious agents were developed with the support of our visiting researchers. In addition, visiting researchers at NIH played a leading role in the identification of the AIDS virus, which enabled us to develop a diagnostic test and begin to bioengineer candidate drugs. These scientists and their successors continue to work with Robert Gallo and others to better understand the molecular mechanisms of the AIDS virus and identify treatment approaches.

Over the years, many visiting scientists have successfully petitioned to continue their careers in the U.S.; some have

gone on to be elected to the National Academy of Sciences and have even been awarded the Nobel Prize. Some have also continued their careers at NIH. In fact, since 1974, 23% of scientists who have been converted from non-tenured to permanent status at the NIH have been foreign nationals. This high percentage is attributable to two trends. First, fewer Americans are entering biomedical research careers; many are opting for careers with greater economic reward. This is clearly reflected in the extramural grant awards made by NIH institutes. There has been a persistent decline in the number of younger applicants for NIH grants: in 1979, more than 26% of all applicants were under 36 years of age; eleven years later this percentage has dropped in half, to less than 13%. Needless to say, the sharp decline in young investigator grant applications is of great concern to NIH and may be an early manifestation of an inadequate national manpower pipeline.

Second, in parallel with this development, visiting researchers are petitioning to remain in the U.S. because either research opportunities are severely limited in their home countries, or if they do exist, these scientists would be unable to transfer the state-of-the-art knowledge gained over the years at the NIH to their home institution. Many of these scientists will point out that they continue to serve the health interests of their country of birth as tenured researchers in Bethesda, or Boston, or Baltimore, since health advances pioneered in U.S.

laboratories transcend national borders and equally benefit their home country.

The flow of international researchers to American laboratories has been a valuable part of the U.S. academic and federal research effort. It has helped NIH to sustain a highly qualified research staff and remain an international leader. Given strong indications that U.S. demand for research staff will unlikely be satisfied by domestic sources, international opportunities to increase our nations's human resources become even more important.

The International Demand for Scientists

Our immigration laws and regulations not only influence access to the available pool of foreign scientists, but determine our ability to compete for the best and the brightest in an international climate of growing demand. Patterns of scientific cooperation among nations point to an international market for investments in research, education and scientific and engineering personnel. As in other markets, investments and people will flow to where opportunities are greatest. The U.S. has historically been a focus of attraction for ambitious and highly capable scientists, who have not only contributed to biomedical advances, but to the U.S. space program, its particle physics laboratories and numerous other science

programs. However, recent trends indicate that the drawing power of the U.S. will be increasingly challenged. A talented researcher seeking the best opportunity to advance in his or her profession will have many international opportunities.

The economic challenge of Japan and neighboring Asian economies to the U.S. has been well-documented and has contributed to decreased U.S. global competitiveness. There is now evidence that naturalized Asian-American scientists are repatriating in increasing numbers due to expanding employment opportunities in their native lands.

The European Community has placed emphasis on scientific manpower development to bolster its competitive stature and has reduced barriers to mobility under the 1992 internal market scheme, which will create greater employment opportunities. This initiative is expected to create some 5-6 million new jobs in the service and R&D sectors. It is prudent to conclude that Europe will not only be able to increase its science and technology workforce, but attract skilled workers from other regions as well. This will occur at a time when the new democracies of Eastern Europe and increased freedom of movement may create unprecedented opportunities for both employers and individuals. The U.S. biomedical community is receiving its first surge of East European applicants for employment in U.S. laboratories.

Finally, Australia, New Zealand and Canada have instituted a merit-based immigration policy to encourage highly-skilled entrants into their workforce. For these nations, immigration policy has become a rational tool for increased economic growth and competitiveness.

Impediments in Current Immigration Policy

When current U.S. immigration policy was framed in 1965, the human resource concerns I have reviewed this morning did not exist. Immigrant streams were relatively low and had little effect on the nation's labor market. However, the U.S. is now the destination of one-half of the world's immigrants, who now account for around one-third of the nation's population growth. The significance of this trend for our economy cannot be overestimated. Mr. Chairman, I believe that without impeding the humanitarian intent of our current policy we can enhance this nation's competitiveness and accelerate advances in scientific research through selective reforms in our immigration policy.

Adoption of a more skill-based immigration policy for professionals whose skills are in short supply would improve the ability of government, academia and industry to meet their manpower needs. Present immigration laws limit our ability to recruit and retain talented scientists. Improvements could be

made in regard to: 1) restrictions on the number of permanent residence visas available for skilled workers in short supply; 2) the current labor certification system; and 3) the administration of the present non-immigrant temporary worker (H-1) and exchange visitor (J-1) visa categories.

Improving the International Science Base

As an important corollary to our efforts to recruit and retain foreign scientists, I would like to draw the Subcommittee's attention to a potentially broader objective of U.S. science policy. I believe that the American public and private sectors should extend their efforts to improve the health research infrastructure of developing nations, so that these countries may in the future offer more professional opportunities for research workers and cultivate an indigenous environment of scientific values and scientific inquiry. Expanding the international science base in biomedicine and other scientific disciplines is especially important, since policy decisions on both a national and global scale are increasingly based on the comprehensive collection and assessment of scientific information.

Improvements in biomedical research capacity globally is to our direct national benefit. The public health emergency of AIDS exemplifies the need for global expertise in health research

and prevention. Our ability to identify, contain, and treat future emerging viral diseases may rely to a large extent on the existence of a network of expertise throughout all continents.

Conclusion

One hundred years ago, when European laboratories were at the forefront of biomedical research, the first Director of the Laboratory of Hygiene, later to become the NIH, travelled to Europe to learn methods for identifying and isolating bacteria. On returning, he soon isolated the cholera vibrio organism endemic to New York and other areas of the U.S. One hundred years later the NIH has become the destination for researchers worldwide to find a cure for the AIDS epidemic and other public health challenges. The great limiting factor which faces us in this critical biomedical enterprise is the human one. We are hopeful that, in an increasingly competitive world, the Congress will enact legislation that will enable this nation to improve its ability to recruit and retain highly-qualified scientists from around the globe.

Thank you Mr. Chairman and Subcommittee members for the opportunity to address these issues. My colleagues at NIH and I would be pleased to provide you with additional information

in order to further support your efforts to strengthen the nation's human resource base in science.

Mr. BROWN. Thank you, Doctor Schambra, for a very stimulating statement.

Doctor Griffiths, you may proceed.

STATEMENT OF DR. PHILLIP A. GRIFFITHS, PROVOST AND JAMES B. DUKE PROFESSOR OF MATHEMATICS, DUKE UNIVERSITY, DURHAM, NORTH CAROLINA

Dr. GRIFFITHS. Thank you, Mr. Chairman. I am Phillip Griffiths, Provost and Professor of Mathematics at Duke University, Chairman of the Board on Mathematical Sciences at the National Research Council, and a member of the National Academy of Sciences. I wish to thank Chairman Valentine, Representative Brown, and the members of the House Subcommittee on Science, Research, and Technology for this opportunity to join my distinguished colleagues to discuss the shortage of scientific manpower and the effect of the immigration laws on science and engineering.

I wish to begin by stating my firm conviction that it is indeed in our Nation's best interest to have the best scientists and engineers, regardless of their country of origin, engaged in scientific inquiry, technology development, and training of the next generation. A hallmark of science is that excellence is sought out and judged on its own merits; therefore, the best minds should be welcomed into the U.S. research establishment. Science has been, and should continue to be, an international enterprise; for it is through the free exchange of ideas, methods, and concepts that seminal contributions to science and technology occur.

While some might wish to take exception to this view and to argue against the presence of foreign nationals in science and engineering at our universities and corporations, I would like to suggest that given the present decline in, and predicted shortages of, scientists and engineers of U.S. citizenship that increasing the number of well-trained, qualified scientists and engineers, regardless of country of origin, should become a national imperative. Our immigration policies can best serve the interests of the Nation if they are reframed to respond to the continuing and growing national demand for individuals with scientific and technical expertise and training.

Simply stated, we face a severe and growing shortage of scientists and engineers. The statistics are frequently quoted but they bear repetition and remembering. The number of employed scientists and engineers doubled between 1976 and 1986, while during the same period the number of Bachelor degrees awarded in these fields increased by just 12 percent. By the year 2010, it is estimated that there will be 60,000 more engineering jobs than there will be engineers to fill them. We anticipate annual shortages of 7,500 natural science and engineering Ph.D.s in the next decade. In my field of mathematics, the current rate at which U.S. citizens achieve doctorates is sufficient to replace retirees only if all Ph.D. recipients accept academic positions. Moreover, it is projected that by 1997 and beyond the demand for mathematics faculty alone will outstrip the supply.

The Board on Mathematical Sciences at the National Research Council is monitoring the situation as it relates to both mathemat-

ics education and research, and recently published two reports, "Renewing U.S. Mathematics: A Plan for the 1990s" and "A Challenge of Numbers: People in the Mathematical Sciences," which describe the issues and present courses of action. I request that executive summaries of these two reports be entered into the record as part of the background for this discussion.

While some of the analyses indicating a shortage of scientists and engineers have not yet taken into account the possible effects of downsizing the military, the numbers are unequivocal—beyond the end of the century there will be significant shortages of man- and woman-power in areas of critical national importance unless foreign-born scientists and engineers supplement the workforce. For it is not so much an issue that we are not training sufficient numbers for our needs, it is that a considerable and increasing percentage of Ph.D. awardees are foreign-born and unavailable to our labor pool.

During the 1980s, for example, the number of Ph.D.'s awarded in science and engineering actually increased by almost 20 percent, but at the same time the number of recipients on temporary visas nearly doubled, and the percentage of Ph.D.s earned by U.S. citizens dropped from 83 percent in 1972 to 71 percent in 1987.

There is a talent pool—a pool made up of both foreign-trained and American-trained foreign nationals. This pool is currently not easily accessible due to overly restrictive immigration policies. Properly modified, however, our immigration policies could become a part of the solution, rather than part of the problem.

Current policies tend to discourage and impede the flow of extremely well-qualified scientists and engineers, preventing easy access to foreign talent. A significant impediment to bringing foreign faculty to our institutions on a permanent visa is the length of time, often in excess of two years, involved in securing permanent resident status. An additional problem occurs because while the INS recognizes the doctrine of dual intent, the Department of State and thereby our consulates do not.

Short term exchanges of Soviet and Eastern block scientists and engineers are slowed by the additional requirements for pre-approval from the Department of State for any Soviet or Eastern European scientists working in a field including the critical technology list. This list includes virtually all fields of science and engineering, with some headings as general as biology, mathematics, earth science, and medical science.

The J-1 visa under which most faculty come on scientific and technical exchanges limits stays to three, and in some instances five, years. At the end of that period, scientists and engineers are expected to spend a minimum of two years in their home country before returning to the U.S. to work.

In the past, doctoral students on F-1 visas were automatically allowed to spend up to three years in full-time postdoctoral training. Recent changes limit training to only twelve months and only the first six months are approved automatically. Pending legislation would eliminate the automatic six-month approval. Similarly, students on J-1 visas are allowed only an 18 month period of practical—or postdoctoral—training. Without a complicated and time-consuming change in visa, these Ph.D.s are not able to remain as

postdoctoral fellows in universities nor to assume positions in industry.

The complexities and burdens of current immigration law require universities interested in foreign graduate students, postdoctoral fellows, and faculty to create an infrastructure and to commit university resources to maintaining expertise in mind-numbing minutiae required to bring and keep foreign nationals in the institution. Universities would far prefer to use their resources to enhance curricula, update facilities, and to provide research instrumentation than to use them to navigate through unnecessarily cumbersome immigration regulations.

I urge you to support the congressional initiatives aimed at facilitating the flow of foreign scientists and engineers. First, I support the creation of an additional and separate pre-permanent visa category, often referred to as the O-visa. I would also urge you to support efforts to restore the post-Ph.D. training period to three years for both J-1 and F-1 student visas, as this constitutes a typical postdoctoral fellowship period. In addition, I would like to see a congressional initiative to have the Department of State recognize the doctrine of dual intent for the purposes of issuing H-1 visas abroad to those intending to remain permanently in the U.S.

While I applaud many of the provisions of H.R. 4300, the Family Unity and Employment Opportunity Immigration Act of 1990, some provisions, if enacted, would present considerable problems to universities and would negatively impact the shortage of scientists and engineers. Representative Morrison's bill also proposes to raise funds to support training for American citizens by levying a \$500 fee per visa application. While the intent to support training is laudatory, the fee may have the unintended result of actually decreasing the number of visa applications from universities.

Mr. Chairman, I appreciate this opportunity to testify before this distinguished committee. The full statement of my testimony will be submitted for the record.

Thank you.

[The prepared statement of Dr. Griffiths and the referenced publications follow:]

House Committee on Science, Space, and Technology
Science, Research and Technology Subcommittee

CONGRESSIONAL HEARING
Increasing U.S. Scientific Manpower

Testimony
by
Phillip A. Griffiths, Ph.D.
Duke University

July 31, 1990

I am Phillip A. Griffiths, Provost and Professor of Mathematics at Duke University, Chairman of the Board on Mathematical Sciences at the National Research Council, and a member of the National Academy of Sciences. I want to thank Chairman Valentine and the Members of the House Subcommittee on Science, Research, and Technology for this opportunity to join my distinguished colleagues, Erich Bloch and Phillip Schambra, to discuss the shortage of scientific manpower and the effect of the immigration laws on science and engineering.

I wish to begin by stating my firm conviction that it is indeed in our nation's interest to have the best scientists and engineers, regardless of their country of origin, engaged in scientific inquiry, technology development, and training of the next generation. A hallmark of science is that excellence is sought out and judged on its own merits; therefore, the best minds should be welcomed into the U.S. research establishment. Science has been, and should continue to be, an international enterprise; for it is through the free exchange of ideas, methods, and concepts that seminal contributions to science and technology occur.

While some might wish to take exception to this view and to argue against the presence of foreign nationals in science and engineering at our universities and corporations, I would like to suggest that given the present decline in, and predicted shortages of, scientists and engineers of U.S. citizenship that increasing the number of well-trained, qualified scientists and engineers, regardless of country of origin, should become a national imperative. Our immigration policies can best serve the interests of the nation if they are reframed to respond to the continuing and growing national demand for individuals with scientific and technical expertise and training.

Simply stated, we face a severe and growing shortage of scientists and engineers. The statistics are frequently quoted, but they bear repetition and remembering.

- The number of employed scientists and engineers doubled between 1976 and 1986,¹ while during the same period the number of bachelors degrees awarded in these fields increased by just 12 percent.²
- By the year 2010, for example, it is estimated that there will be 60,000 more engineering jobs than there will be engineers to fill them.
- We anticipate annual shortages of 7,5000 natural science and engineering Ph.D.s in the next decade.³

¹ from 2.3 million to 4.6 million; *A Challenge of Numbers: People in the Mathematical Sciences*, National Academy Press, Washington, D.C., 1990, p. 113.

² *Science and Technology in the Academic Enterprise*, National Research Council Government-University-Industry Roundtable, National Academy Press, Washington, D.C., 1989, p. 2-61.

³ Bowen, William G. and Sosa, Julie Ann, *Prospects for Faculty in the Arts and Sciences: Factors Affecting Supply and Demand 1987-2012*, Princeton University Press, Princeton, N.J., 1989, p. 128.

- In my field of mathematics, the current rate at which U.S. citizens achieve doctorates is sufficient to replace retirees only if essentially all Ph.D. recipients accept academic positions.
- Moreover, it is projected that by 1997 and beyond the demand for mathematics faculty alone will outstrip the supply by 1,841.⁴

The Board on Mathematical Sciences at the National Research Council is monitoring the situation as it relates to both mathematics education and research, and recently published two reports, *Renewing U.S. Mathematics: A Plan for the 1990s*⁵ and *A Challenge of Numbers: People in the Mathematical Sciences*,⁶ which describe the issues and present courses of action.

While some of the analyses indicating a shortage of scientists and engineers have not yet taken into account the possible effects of downsizing the military, the numbers are unequivocal: beyond the end of the century there will be significant shortages of man- and woman-power in areas of critical national importance unless foreign-born scientists and engineers supplement the work force. For it is not so much an issue that we are not training sufficient numbers for our needs, it is that a considerable and increasing percentage of Ph.D. awardees are foreign-born and unavailable to our labor pool. During the 1980s, for example, the number of Ph.D.'s awarded in science and engineering actually increased by almost 20 percent, but at the same time the number of recipients on temporary visas nearly doubled⁷ and the percentage of Ph.D.s earned by U.S. citizens dropped from 83 percent in 1972 to 71 percent in 1987. There is a talent pool—a pool made up of both foreign-trained and American-trained foreign nationals. This pool is currently not easily accessible due to overly restrictive immigration policies. Properly modified, however, our immigration policies could become a part of the solution, rather than part of the problem.

Current policies tend to discourage and impede the flow of extremely well-qualified scientists and engineers, preventing easy access to foreign talent.

- A significant impediment to bringing foreign faculty to our institutions on a permanent basis is the length of time, often in excess of two years, involved in securing permanent resident status. While it is possible for prospective permanent faculty to come on an H-1 (one of many temporary visas), few faculty of quality would elect to relinquish a chaired professorship at Oxford or a senior staff appointment at the Max Plank Institute on the hope and promise of permanent resident status at some point in the future.

⁴ Bowen and Susa, *Op Cit*, Table 7.6.

⁵ *Renewing U.S. Mathematics: A Plan for the 1990s*, National Academy Press, Washington, D.C., 1990.

⁶ *A Challenge of Numbers: People in the Mathematical Sciences*, National Academy Press, Washington, D.C., 1990.

⁷ *Summary Report 1988*, Survey of Earned Doctorates Project, National Research Council, National Academy Press, Washington, D.C., 1989, p. 8.

- An additional problem occurs because while the INS recognizes the doctrine of dual intent, the Department of State and thereby our consulates do not. For example, if a faculty member on an H-1 visa who has applied for permanent residency wishes to go abroad to deliver a paper at a conference, his or her request for an H-1 visa with which to return to the U.S. can be denied because of their pending permanent residency application. We usually advise members of the Duke community in this position to remain in the U.S. until their permanent residency is approved, thus denying them mutually beneficial contact with colleagues abroad and access to the latest advances and techniques.
- Short-term exchanges of Soviet and Eastern-block scientists and engineers are slowed by the additional requirements for pre-approval from the Department of State for any Soviet or Eastern European scientist working in a field included on the Critical Technology List. The list includes virtually all fields of science and engineering, with some headings as general as biology, mathematics, earth science, and medical science.
- The J-1 visa under which most faculty come on scientific and technical exchanges limits stays to three, and in some instances five, years. At the end of that period, scientists and engineers are expected to spend a minimum of two years in their home country before returning to the U.S. to work. Many who might have contributed significantly to our efforts never return. Others petition their governments for approval to remain, only to have their waivers denied by USIA. This is especially common when Fulbright monies have been involved.
- In the past, doctoral students on F-1 visas were automatically allowed to spend up to three years in full-time postdoctoral training. Recent changes limit training to only 12 months and only the first six months are approved automatically. Pending legislation would eliminate the automatic six-month approval. Similarly, students on J-1 visas are allowed only an 18-month period of practical—or postdoctoral—training. Without a complicated and time-consuming change in visa, these Ph.D.s are not able to remain as postdoctoral fellows in universities nor to assume positions in industry. The postdoctoral training period is often one of the most productive periods of a scientist's life and thus, the loss of access to this pool of talent is serious.
- The complexities and burdens of current immigration law require universities interested in foreign graduate students, postdoctoral fellows, and faculty to create an infrastructure and to commit university resources to maintain expertise in the mind-numbing minutiae required to bring and keep foreign nationals in the institution. At Duke University, for example, we have three—and need at least five—full-time employees who serve as international advisors and whose chief concern is the visa status of our international visitors and foreign faculty. Considerable additional financial resources are expended by both our in-house legal staff and by outside specialists to expedite necessary status changes and visa extensions. Universities would far prefer to use their resources to enhance curricula, to update facilities, and to provide research instrumentation than to use them to navigate through unnecessarily cumbersome immigration regulations.

I urge you to support the congressional initiatives aimed at facilitating the flow of foreign scientists and engineers. First, I support the creation of an additional and separate pre-permanent visa category, often referred to as the O-visa. This could be used to facilitate the entry of tenure-track and tenured faculty who intend to remain permanently. I would also urge you to support efforts to restore the post-Ph.D. training period to three years for both J-1 and F-1 student visas, as this constitutes a typical post-doctoral fellowship period. Restrictions on American-trained, foreign-born students should be relaxed to enable them to remain in the U.S. for postdoctoral fellowships. In addition, I would like to see a congressional initiative to have the Department of State recognize the doctrine of dual intent for the purpose of issuing an H-1 visa abroad to those intending to remain permanently in the U.S. Annually, the number of permanent residencies granted is limited currently to 270,000 with only 10 percent reserved for professionals; I urge you to work to increase this number and to address the special national need for scientists and engineers.

While I applaud many of the provisions of HR 4300, *Family Unity and Employment Opportunity Immigration Act of 1990*, some provisions, if enacted, would present considerable problems to universities and would negatively impact the shortage of scientists and engineers. While the bill proposes a simplification of the process through which an individual changes from nonimmigrant to permanent residency status, it also caps the number that can be admitted to 25,000. Since under this cap, universities would be competing with industry and, for example, the world of entertainment, an exemption for holders of Ph.D.s would greatly enhance the position of universities in hiring foreign faculty. Representative Morrison's bill also proposes to raise funds to support training for American citizens by levying a \$500 fee per visa application. While the intent to support training is laudatory, the fee may have the unintended result of actually decreasing the number of visa applications from universities.

An easing of immigration law and the raising of the annual immigration limits on scientists, engineers, and other skilled workers will, I believe, impact significantly on the projected shortage of scientists and engineers. Currently, roughly 45 percent of engineering Ph.D.s are awarded to foreign nationals (as compared to 30 percent in 1978 and 16 percent in 1958). This talent pool, nurtured and frequently supported by American faculty, facilities, and funding, should not be lost to the American scientific and technological enterprise due to misplaced concerns about labor competition.

Although, as I stated at the outset, I firmly believe that America will be best served by excellence in science and engineering regardless of national origin, I do not mean to imply that relying on foreign-born talent to fill critical shortages is an appropriate long-term national strategy.

Our current shortage of scientists and engineers reflects a crisis in science education, in the public perception of the status of scientists and engineer, and in the federal support of basic research which must be addressed. Together, the scientific community and the federal government need to work for the long-term solution of the manpower shortage. In order to significantly increase the numbers of U.S. citizens entering the so-called "science pipeline," we must honestly examine reasons why American students are turned off to science and engineering.

Scientists and engineers in colleges and universities, in national laboratories, and in industry need to reach into grades K-12 to make science and engineering real and interesting and to sustain students' early enthusiasm for science and mathematics. The process of scientific discovery is fun and exciting. This sense of excitement must be communicated to our youth, but all too often it is lost in the grind of facts and figures. At colleges and universities and in continuing cooperation with organizations such as the National Science Foundation and the National Academy of Sciences, we need to radically reassess our curricula from pre-school through the baccalaureate. And, even in our top research universities, where often rewards are based upon research accomplishments, new structures for properly recognizing and rewarding pedagogy should be instituted.

The scientists and engineers, the researchers and the teachers cannot alone reverse the trend away from careers in science and technology. The federal government must act as their partner. In addition to encouraging graduate study in science and engineering through additional programs of fellowship support, the government must improve the general climate for conducting science in this country, a climate which currently discourages potential scientists from entering or remaining in academic science. There are excellent scholars—both American and foreign-born—who are unable to prosper with the current funding, but whose contributions to science could be remarkable. Moreover, students observe faculty struggling to get research grants, struggling to support laboratory personnel, and these faculty serve as negative or reverse role models—pushing interested students into careers in medicine rather than biology or business rather than engineering.

We agree, I believe, that science and engineering expertise and knowledge are the essential building blocks of our nation's economic competitiveness. Without a steady, reliable, and well-trained work force we shall lag behind. That, we can ill afford. Together we must address the issues of science education and stable, adequate research funding to increase the flow of native-born scientists and engineers with particular attention given to candidates from nontraditional talent pools—women and minorities. In the near term, the shortage of scientists and engineers can be eased by the availability of foreign-born faculty. I, therefore, urge this subcommittee to work with that of Chairman Morrison on Immigration, Refugees, and International Law to modify our immigration laws with special attention to the needs of science, engineering, and technology and with special sensitivity to the role and needs of the nation's colleges and universities. But I would also like to remind this committee that excellence in science is not determined by country of origin and would therefore urge that the changes in the immigration laws not be limited to times of manpower shortage. We can but benefit by continued access to the best minds. Thank you.

Renewing U.S. Mathematics

A PLAN FOR THE 1990s

Executive Summary



Board on Mathematical Sciences
National Research Council

The National Research Council established the Board on Mathematical Sciences in 1984. The objectives of the Board are to maintain awareness and active concern for the health of the mathematical sciences and to serve as the focal point in the National Research Council for issues affecting the mathematical sciences. The Board holds symposia and workshops and prepares reports on emerging issues and areas of research, conducts studies for federal agencies, and maintains liaison with the mathematical sciences communities, academia, professional societies, and industry.

The Board on Mathematical Sciences gratefully acknowledges ongoing core support and support for this study from the following federal agencies of ICEMAP (Interagency Committee for Extramural Mathematics Programs):

- Air Force Office of Scientific Research
- Army Research Office
- Department of Energy
- National Science Foundation
- National Security Agency
- Office of Naval Research

The Board gratefully acknowledges support from the National Research Council for the dissemination of this report.

Renewing U.S. Mathematics

A PLAN FOR THE 1990s

Executive Summary

Committee on the Mathematical Sciences:

Status and Future Directions

Board on Mathematical Sciences

Commission on Physical Sciences, Mathematics, and Applications

National Research Council

NATIONAL ACADEMY PRESS

Washington, D.C. 1990

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The National Academy of Sciences is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Frank Press is president of the National Academy of Sciences.

The National Academy of Engineering was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Robert M. White is president of the National Academy of Engineering.

The Institute of Medicine was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Samuel O. Thier is president of the Institute of Medicine.

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NATIONAL RESEARCH COUNCIL

2101 CONSTITUTION AVENUE WASHINGTON, D. C. 20418

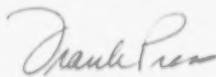
OFFICE OF THE CHAIRMAN

This report, Renewing U.S. Mathematics: A Plan for the 1990s, updates the 1984 "David Report," which recommended a national plan to renew and ensure the health of the U.S. mathematical sciences enterprise. The new report, presenting the committee's assessment of progress made since 1984, communicates a sense of promise and achievement, but also the conviction that further corrective action is urgently needed to ensure the vitality of U.S. mathematics.

Substantial progress can be seen in increased federal support for graduate education and postdoctoral researchers, as well as in stronger leadership and improved cohesiveness within the mathematical sciences community. Yet major problems remain: the continuing inadequacies in support for mathematical sciences research, especially for principal investigators; the slow response on the part of many members of the mathematical sciences community to the serious issues of renewal; and the absence of a concerted response by universities to problems clearly described six years ago. The high drop-out rate from mathematical sciences career paths warns that U.S. mathematical research faculties, institutions, and education at all levels must be renewed.

At the same time, this report's presentation of some of the exciting recent achievements in mathematical sciences research, as well as the wealth of opportunities for future research and applications, points to the promise of what is achievable in the mathematical sciences and by extension in U.S. science and technology.

We have an opportunity now to deal with the issues confronting the mathematical sciences community and the nation, especially the challenge of attracting and educating tomorrow's professors and researchers. This report recommends specific actions to address those issues. I commend it to your attention.



Frank Press
Chairman
National Research Council

NATIONAL RESEARCH COUNCIL

COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND APPLICATIONS

2101 Constitution Avenue Washington, D.C. 20418

BOARD ON MATHEMATICAL SCIENCES

April 1990

Dr. Frank Press
Chairman, National Research Council

Dear Frank:

In submitting to you the report of the Committee on the Mathematical Sciences: Status and Future Directions, let me include some comments and observations which are unusual for a letter of transmittal. I do so in hopes that their message will be promulgated and heard, not only in the National Academies but more widely.

Nine years ago you asked me to chair the Ad Hoc Committee on Resources for the Mathematical Sciences, to review the intellectual health of mathematical research in the United States and do an in-depth analysis of federal support for the field. As a communications engineer who could trace his roots back through his thesis advisor Jerry Wiesner to the great mathematician Norbert Wiener, and as a science administrator who had seen first-hand the enormous impact of mathematics and mathematicians, first at Bell Laboratories and later at Exxon Research and Engineering, I was pleased to accept. You gave me a superb committee to do the work.

You are as familiar as I am with what we found: a field brimming with intellectual vitality, preeminent in the world, and poised to make even greater contributions to science and technology, yet a field in which the research infrastructure had eroded, in part because federal support had been allowed to deteriorate. In 1984 the ad hoc committee recommended a coordinated set of actions to be taken by government, universities, and the mathematical community over five to ten years to rebuild the infrastructure and enable mathematics to renew itself.

Halfway through that decade you asked me to chair a different but equally distinguished committee, on behalf of which I am now reporting. We were to assess progress made in implementing the 1984 recommendations. I was happy to accept because I remain vitally concerned with the health of U.S. mathematics. Our report tells what has happened in the five years since we published Renewing U.S. Mathematics: Critical Resource for the Future, and this second report recommends what to do now. Our message is in one sense very simple: balance between support for the mathematical sciences and support for related fields must be restored; stay the course, see it through. We do suggest, however, a modification of the original plan for renewal, tying it more closely to human resource issues and concentrating attention on the pipeline which develops mathematical and scientific

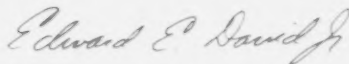
talent--issues which loom much larger in the minds of all of us today than they did five years ago. This modification may require some policy changes in federal agencies, drawing their research and educational missions closer together. It will certainly require strong commitment and bold action by the mathematical sciences community, working in conjunction with the research universities.

Let me end with a personal perspective. Overall, I am both pleased and puzzled by progress since 1984--pleased because strong leadership by individuals in government and the mathematical sciences community has brought substantial progress, creating movement toward renewal, yet puzzled by three matters:

1. the general membership of the mathematical sciences community, unlike its leadership, seems only beginning to grasp either the nature or seriousness of its renewal problems, problems that are being compounded by the greatly increased need to attend to revitalization of mathematics education;
2. the lack of concerted action by the research universities or their leaders, either in calling attention to the problems of mathematical research funding or in bolstering their mathematical sciences departments; and
3. the inability of the science policy mechanisms of government to deal decisively with a funding problem as easily soluble and vitally important as the one we pointed out back in 1984.

On the first point, I plan to continue the work I began five years ago, of encouraging the mathematical sciences community to act vigorously, and am happy to see the intense dialogue which is shaping up for 1990 within the community. As former directors of the Office of Science and Technology Policy, we are not very surprised by points 2 and 3. But, for my own part, I remain somewhat distressed by them. Perhaps we can join together in carrying a message to government and the universities. If the mechanisms of science policy cannot solve this critical problem in mathematics, it is doubtful whether they can solve any problem at all.

Sincerely,



Edward E. David, Jr.
Chairman, Committee on the
Mathematical Sciences

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Acknowledgments

Many individuals in and beyond the mathematical sciences community contributed to this report. The interdisciplinary Committee on the Mathematical Sciences: Status and Future Directions, which developed the ideas that form the writing and core of this report, actively and willingly participated in the creation of it, as is reflected in its finished form. Their names are listed on a previous page. I particularly acknowledge Calvin C. Moore, vice-chair of the committee, for seeking out, selecting among, organizing, and presenting well a diverse collection of research opportunities in the mathematical sciences. For a field that offers so many rich opportunities for the future, this was a challenging task. Thanks are due also to some 40 mathematical scientists for providing written expert summaries. These summaries provided much of the substance for the section titled "Accomplishments and Opportunities."

The committee had before it a great deal of information that influenced its conclusions. Much of that information is not contained in the report itself since it will appear elsewhere. The committee thanks those who brought it forward, often at considerable effort. Among them are the directors, deputy directors, and staff of the ICMAP federal agencies, and William G. Rosen and other members of the staff of the Board on Mathematical Sciences. The chairpersons of some 25 university mathematical sciences departments furnished detailed data on their departments as compared to physics, chemistry, biology, and engineering departments. The committee also wishes to thank four chairpersons in particular who, through thoughtful essays, provided valuable glimpses of conditions for fulfilling the research and education goals of the mathematical sciences.

ACKNOWLEDGMENTS

Thanks are due to the National Science Foundation and the other ICEMAP federal agencies for commissioning this study and to the Board on Mathematical Sciences, National Research Council (NRC), for organizing it. The board supplied valuable information and advice concerning both the research opportunities and wider matters, through its chairperson, Phillip A. Griffiths, and participants Guido L. Weiss, Peter J. Bickel, and Cathleen S. Morawetz.

Conscientious and effective support was given to the committee by the board's staff, particularly by its Executive Director, Lawrence H. Cox, and Senior Staff Officer Scott T. Weidman. The attention to detail yet quick response of the NRC offices responsible for the review and production of the report, and of the independent reviewers of the report assigned by the NRC, also deserve mention as constructive influences.

Edward E. David, Jr.
*Chairman, Committee on the
Mathematical Sciences*

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Executive Summary

RENEWING U.S. MATHEMATICS—THE 1984 REPORT

In 1981 a committee of the National Research Council was formed to investigate the health of the mathematical sciences¹ in the United States. Its 1984 report, *Renewing U.S. Mathematics: Critical Resource for the Future* (the "David Report"),² found that although the field was thriving intellectually, government support had deteriorated to a dangerously low level. Moreover, the number of young people entering the mathematical sciences had decreased to a level inadequate to replenish the field. In particular, the number of productive mathematical scientists was projected to decline sharply in the 1990s when the current generation of senior researchers retires. This decline was expected to have serious consequences for the nation's scientific and engineering research effort because of the fundamental role of mathematics in the exact sciences. Today a shortage of mathematicians takes on added urgency as we recognize mathematics education as a national priority.

The 1984 Report recommended a plan for renewal, the National Plan for Graduate and Postdoctoral Education in the Mathematical Sciences. That plan's essential feature was a call for funding to bring support for the mathematical sciences into balance with support for the physical sciences and engineering. The interdisciplinary committee that wrote the 1984 Report quickly realized that the low level of research support for U.S. mathematical sciences was so severe that it threatened the vitality of the entire scientific enterprise: the enormous disparity in the number of people supported in the mathematical sci-

ences vis-à-vis other sciences and engineering meant that support for the overall science and technology base was in poor balance, thus threatening its effectiveness. Solving the problem of inadequate support for the mathematical sciences was therefore necessary as much to restore a healthy balance to the nation's scientific enterprise as to assure a healthy mathematics research capability. Without attempting to define "ideal" balance, the 1984 Report recommended levels of support for research and researcher training in the mathematical sciences that would eliminate at least the gross imbalance documented there. Their actions in response to the 1984 Report make it clear that the mathematical sciences community and the federal funding agencies have accepted the conclusions that an imbalance existed and needed to be countered.

THE CURRENT REPORT—A PLAN FOR THE 1990s

As requested by the National Science Foundation (NSF) and the Inter-agency Committee for Extramural Mathematics Programs (ICEMAP), this report updates the 1984 Report. Specifically, the charge directed the committee to (1) update that report, describing the infrastructure and support for U.S. mathematical sciences research; (2) assess trends and progress over the intervening five years against the recommendations of the 1984 Report; (3) briefly assess the field scientifically and identify significant opportunities for research, including cross-disciplinary collaboration; and (4) make appropriate recommendations designed to ensure that U.S. mathematical sciences research will meet national needs in coming years.

Of the several components of the mathematical sciences community requiring action, its wellspring—university research departments—is the primary focus of this report.³ The progress and promise of research—described in the 1984 Report relative to theoretical development, new applications, and the refining and deepening of old applications—have if anything increased since 1984, making mathematics research ever more valuable to other sciences and technology.

However, although some progress has been made since 1984 in the support for mathematical sciences research, the goals set in the 1984 Report have not been achieved (Table A). Practically all of the increase in funding has gone into building the infrastructure, which had deteriorated badly by 1984. While graduate and postdoctoral research, computer facilities, and new institutes have benefited from increased

EXECUTIVE SUMMARY

TABLE A Federal Support of Mathematical Sciences Research—Progress Over Five Years, 1984 to 1989

Category of Support	1984 National Plan Goal	1984 Level	1989 Level	Percent Change, 1984 to 1989	Percent of 1984 National Plan Goal Reached by 1989
Number of researchers supported					
Senior investigators	2600	1800	1900	+6	73
Postdoctoral researchers	400 ^a	132	188 ^b	+42	47
Graduate research assistants	1000	411	661 ^b	+61	66
Total dollars (millions)	225 ^c	99.6 ^d	133	+34	59

^aThe 1984 National Plan calls for awarding 200 two-year postdoctorals annually, resulting in a population of 400 at any given time.

^bMost recent counts comparable to the 1984 numbers, from fall 1988. (NSF Division of Science Resources Studies, personal communication.)

^c1984 National Plan goal adjusted for inflation using Higher Education Price Index; revised National Plan goal is \$250 million.

^dIn 1989 dollars, using Higher Education Price Index.

resources, some of these areas are still undersupported by the standards of other sciences (Table B). And in the area of research support for individual investigators, almost no progress has been made. A critical shortage of qualified mathematical sciences researchers still looms, held at bay for the moment by a large influx of foreign researchers, an uncertain solution in the longer term.

While government has responded substantially to the 1984 Report's recommendations, particularly in the support of infrastructure, the universities generally have not, so that the academic foundations of the mathematical sciences research enterprise are as shaky now as in 1984. The greatest progress has been made in the mathematical sciences community, whose members have shown a growing awareness of the problems confronting their discipline and increased interest in dealing with the problems, particularly in regard to communication with the public and government agencies and involvement in education.

TABLE B Selected Indicators of Imbalance in Research Support

	Chemistry	Physics	Mathematical Sciences
Percent of R&D faculty with federal support, 1987	56	75	37
Number of postdoctorals with federal support, 1988	2587	1280	188
Percent of graduate students with research support, 1987	49	51	18

SOURCES: Faculty percentages from National Research Council, Survey of Doctorate Recipients project (personal communication); other entries from National Science Foundation, Division of Science Resources Studies (personal communication).

In addition to being essential to the continued vitality of U.S. science and technology, addressing the problems of the health and renewal of the U.S. mathematical sciences research enterprise offers the added benefit of contributing directly to solving the critical problems of mathematics education in America. Without the vital nerve center of a healthy and self-renewing research enterprise in university mathematical sciences departments, all the other aspects of our necessary national effort to improve mathematics education will be slowed and inhibited. The need for replenishment of university research faculties is greater and more uncertain in the decade of the 1990s than ever before, and the effects of a deterioration will be felt not only in research production, but also in the educational preparation of scientists and engineers generally, of mathematical scientists and teachers, and of a scientifically and mathematically literate public.

EXECUTIVE SUMMARY

CONCLUSIONS AND RECOMMENDATIONS

I. Implement the 1984 Report's National Plan

Conclusion: Progress has been made in carrying out the 1984 Report's National Plan, but support for the mathematical sciences remains seriously out of balance with that for the other sciences and engineering. The numbers of supported senior investigators, graduate research assistants, and postdoctoral researchers are still seriously out of line with the numbers supported in other sciences of comparable size.

Since 1984 there have been significant increases in support for mathematical sciences graduate student and postdoctoral researchers, but no meaningful increase in the number of senior researchers supported. The numbers of currently supported graduate student and postdoctoral researchers are still far short of the goals set in the 1984 National Plan, and the number of senior researchers supported remains approximately 700 short of the goal.

The National Science Foundation has substantially increased support for the mathematical sciences, as has the Department of Defense, which has established new programs at the Defense Advanced Research Projects Agency and the National Security Agency. The Department of Energy has funded a major effort in computational mathematics. Other government agencies have provided only moral support. The mathematical sciences community has responded actively to the challenges posed in the 1984 National Plan.

Recommendation I: Fully implement the 1984 National Plan while increasing the level of annual federal funding for the mathematical sciences to \$250 million from \$133 million (in 1989 dollars) over the next three years. The 1984 National Plan's goal of \$180 million per year has risen due to inflation to \$225 million, to which is added \$25 million per year for implementing the second thrust of Recommendation II, below.

II. Improve the Mathematical Sciences Career Path

Conclusion: The rate at which young people enter the mathematical sciences remains inadequate to renew the field.

The attrition rate for students in the mathematical sciences is 50% per year, the highest among all scientific fields. The recent report by W.G. Bowen and J.A. Sosa⁴ predicts a severe shortage of mathematical and physical scientists for academic positions during the 1990s. Similar shortages are expected for government and industrial positions. This committee believes that bright young people are discouraged from pursuing careers in the mathematical sciences because they find their career prospects are dim. Mathematical sciences departments in universities provide much less opportunity for research, fewer graduate research assistantships, and far fewer postdoctoral research positions than do other science departments. Students are quick to perceive this.

Corrective action is needed to assure an adequate supply of talented students for the mathematical sciences. Professors must show students that the mathematical sciences offer both intellectual excitement and attractive career prospects. Providing intellectual excitement is the responsibility of the mathematical sciences community. To perceive attractive career prospects, students must see in their own mathematics departments active, successful research enterprises that involve graduate students, young faculty, and senior researchers, all supported at levels competitive with those in the other sciences and engineering.

Recommendation II: Improve the career path in the mathematical sciences. Specifically,

- The funding called for in Recommendation I should be used to increase the numbers of senior, junior, and postdoctoral researchers, and graduate research assistants supported. This committee reiterates the 1984 call for annual federal support for 2600 senior investigators, 200 new postdoctoral researchers, 1000 graduate research assistants, and 400 research grants for young investigators.⁵ At these levels of support the mathematical sciences would be renewed by an influx of fresh talent, and the nation could realize fully the scientific potential of some 700 first-rate senior researchers who now lack federal support. Finally, funding for the mathematical sciences would be brought into balance with levels of funding for other science and engineering fields. Until the present clear imbalance is countered, students will continue to find the mathematical sciences less attractive than other fields, and renewal of U.S. mathematics will fail.

EXECUTIVE SUMMARY

- **Ten percent of the funding called for in Recommendation I should support coherent programs that directly encourage young people to enter and remain in mathematical sciences careers.** Recruitment of women and minorities into the mathematical sciences is a high priority. The NSF and other government agencies should solicit research proposals for programs that will improve the career path. Such proposals may combine research opportunities for students, postdoctorals, and young faculty with increased support for senior researchers who can act as mentors. Proposals may be submitted by whole departments, faculty groups (possibly with members from different departments), or individuals. Special criteria may be required to judge such proposals.

- **Academic mathematical sciences departments should give increased recognition to faculty who act as mentors for students and junior colleagues, who contribute to education, and who interact with collaborators from other disciplines.** This change would encourage efforts to improve the teaching of mathematics both at the undergraduate and graduate levels.

- **Universities should do more to strengthen their mathematical sciences departments.** Universities should give these departments adequate resources to meet the responsibility of preparing large numbers of science and engineering students while also providing adequate resources for research training in the mathematical sciences.

III. Support a Sufficient Number of Individual Investigators

Conclusion: Mathematical sciences research has been extraordinarily productive over the past five years.

Striking progress has been made along a broad front, from the most abstract branches of core mathematics to computer algorithms for the most practical problems. Appendix B of this report documents some of the main trends. As remarkable as recent mathematical research has been, a substantially greater rate of progress is possible because the mathematical sciences enterprise is running well below its attainable productivity. Most mathematical sciences research is done by some 2600 highly active investigators—a conservative estimate⁶—of

whom about 700 are entirely unsupported by federal funds. A substantial fraction of these 700 lack even the two months of uninterrupted research time provided by typical grants. Because these mathematical scientists are highly productive, small investments in support can produce large payoffs in the form of major advances. Since the mathematical sciences have so strong an impact on science and technology, this opportunity should not be wasted.

Recommendation III: Increase to 2600 the number of mathematical sciences senior investigators supported annually. As explained in Conclusion II, this is also a basic step to meeting the problems of renewal. It is the one funding recommendation in the 1984 National Plan on which no meaningful action has been taken. The time has come to take full advantage of the remarkable scientific opportunities offered by the mathematical sciences.

These overarching recommendations suggest particular actions—by federal agencies, universities, department chairs and university administrators, and the mathematical sciences community—that are specified in Chapter 5 of the full report.

Underpinning these recommendations, and adding urgency to them, is the belief held by the committee that a vigorous mathematical sciences research enterprise is crucially important to the task of upgrading mathematics instruction in our primary and secondary schools and at the collegiate level. As Morris Tanenbaum, vice-chairman of AT&T and a member of this committee, expressed it:

Everything you read about our children's education makes you weep because so many of them can't add, subtract, or understand a simple formula. Everything you read says that many of their TEACHERS can't teach them those simple, necessary skills. You ask: "Where do the teachers come from?" The teachers come from undergraduate schools, where they haven't had any significant education in mathematics. Then you ask: "Who teaches the teachers? Who will really teach them from a first-rate point of view?" Their professors must come from good schools that attract and educate people who are truly interested in mathematics. All the information we've seen tells us that the community that produces professors in the mathematical sciences is threatened, and weak, and should be rebuilt.

Mathematics plays an essential role at all levels of the educational process, particularly in science and engineering. We must have excellence at the top to have excellence down the line. Research mathematicians train gradu-

EXECUTIVE SUMMARY

ate students who go on to teach in the nation's colleges. Mathematics researchers receive their training from active researchers in university research departments. So, too, do most college teachers, whether they become researchers or not. U.S. postsecondary mathematics education and mathematics research are interdependent, and the university department is their nexus. College teachers in turn train the next generation of primary and secondary school mathematics teachers. This process is producing too few teachers who are qualified to teach mathematics. Yet it is at the primary and secondary school levels that students often decide that they can or cannot undertake careers in science or engineering. Today mathematics is too often a barrier that discourages students from making ambitious career choices. This is particularly true for minority and women students. Major initiatives in mathematics of the kind recommended in this report thus play a crucial role in strengthening mathematics education at all levels and hence in assuring that the United States will be internationally competitive. *Indeed, the committee believes that the health and vigor of the mathematical sciences is a vital index in judging the prospects for national attempts to solve the science-based problems of U.S. society.*

NOTES

¹The discipline known as the mathematical sciences encompasses core (or pure) and applied mathematics, plus statistics and operations research, and extends to highly mathematical areas of other fields such as theoretical computer science. The theoretical branches of many other fields—for instance, biology, ecology, engineering, economics—merge seamlessly with the mathematical sciences.

²National Research Council, *Renewing U.S. Mathematics: Critical Resource for the Future* (National Academy Press, Washington, D.C., 1984).

³Additional reports on critical issues in the mathematical sciences are forthcoming from the Mathematical Sciences in the Year 2000 Committee, whose final report late in 1990 will detail many crucial recruitment and education reforms needed into the twenty-first century.

⁴Bowen, W.G., and Sosa, J.A., *Prospects for Faculty in the Arts & Sciences* (Princeton University Press, Princeton, N.J., 1989).

⁵These goals, developed in the 1984 Report, pp. 57-65, were examined by the committee and found to be still valid today.

⁶National Research Council, *Renewing U.S. Mathematics*, 1984, pp. 61-64.

A CHALLENGE OF NUMBERS

People in the Mathematical Sciences

EXECUTIVE SUMMARY

A CHALLENGE OF NUMBERS

People in the Mathematical Sciences

EXECUTIVE SUMMARY

Prepared by
Bernard L. Madison
for the
Committee on the Mathematical Sciences
in the Year 2000

Mathematical Sciences Education Board
Board on Mathematical Sciences
Commission on Physical Sciences, Mathematics, and Resources
National Research Council

National Academy Press
Washington, D.C. 1990

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

The National Academy of Sciences is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Frank Press is president of the National Academy of Sciences.

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The Committee on the Mathematical Sciences in the Year 2000, which was appointed at the beginning of 1988, is a three-year project of the Mathematical Sciences Education Board and the Board on Mathematical Sciences. Its purpose is to provide a national agenda for revitalizing mathematical sciences education in U.S. colleges and universities.

Support for this project and for the publication and dissemination of this report was provided by grants from the National Science Foundation and the National Security Agency.

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Preface

During the last decade of this century, the U.S. educational system will face many challenges, but few more important than the renewal and revitalization of the mathematical sciences. Problems in mathematical sciences education exist at all levels—elementary, high school, and postsecondary. These problems are caused by many factors, including a static curriculum, insufficient resources devoted to instruction, inadequate numbers of well-trained teachers, declining student interest, and more generally, the public's failure to understand fully the importance of education in science for the well-being of our society. The problems manifest themselves in the product of the educational enterprise—the scientifically trained work force that must serve the needs of our society. The demands of the next decade and the twenty-first century will require that large numbers of America's work force be equipped with higher levels of mathematical sophistication. Yet, the National Science Foundation and other organizations project that by the year 2000, unless there is a dramatic change, our nation will face a significant shortfall of people with the necessary skills in the mathematical sciences.

In response to this crucial situation the National Research Council has established the Committee on the Mathematical Sciences in the Year 2000, under the direction of the Mathematical Sciences Education Board and the Board on Mathematical Sciences, to assess the present state of collegiate education in the mathematical sciences, to identify existing problems, and to recommend action that can remedy this situation. It is hoped that this analysis by the committee will lead to a national agenda for renewal and revitalization of the mathematical sciences and to a strategy for implementation that will stimulate all sectors of our society into action.

The present descriptive report, *A Challenge of Numbers*, is one of three planned by the committee. It describes the circumstances and issues related to the human resources in the mathematical sciences, principally students and teachers at U.S. colleges and universities. The mathematical sciences, based largely in academia, are crucial not only for the development of new knowledge but also as a needed resource in the education of our technological work force. As with other scientific professions, the challenge of meeting the growing need for workers in the face of shrinking supplies will require a program of national action, but the situation in the mathematical sciences is particularly severe. Attrition from the educational pipeline in mathematics has given rise to low degree production at all levels in colleges and universities, and socioeconomic forces have resulted in unprecedentedly low interest in mathematics as a major among entering freshmen. At the same time, growing enrollments in lower-level mathematics courses with small or no increases in staffing levels have created less than an ideal environment for faculty in the mathematical sciences. Because of the fundamental role of mathematics in support of science and engineering, the problems in the U.S. educational system will not be corrected unless the problems in mathematics education are corrected. On the other hand, a revitalization of the mathematical sciences could lead the way in effecting change across the educational spectrum.

A Challenge of Numbers contains data from a large number of existing sources. It provides in one place a comprehensive set of data describing the demographic situation in the mathematical sciences. This report does not provide answers, nor does it draw conclusions. Rather, it serves as a reference. As such, it will be an important source of data for the Committee on the Mathematical Sciences in the Year 2000 in formulating its recommendations. Also, it is hoped that the report will be used by educators and administrators in industry, government, and education to alert policymakers about the urgent need for revitalization of the mathematical sciences.

This is the second report of the MS 2000 project. The first, *Everybody Counts*, was published jointly with the Mathematical Sciences Education Board and the Board on Mathematical Sciences and provided a general analysis of the trends and needs in mathematics education. The next review paper, to be published in late spring 1990, will assess the college and university curriculum, and the final paper, due in summer 1990, will report on resources available for instruction in the mathematical sciences. Following the completion of the review papers, the Committee on the Mathematical Sciences in the Year 2000 will be in a position to issue its final recommendations in a report to the nation scheduled for late 1990.

On behalf of the committee, I want to express our gratitude to Bernard L. Madison and Therese A. Hart for their work in compiling the necessary background information and for writing *A Challenge of Numbers*. They have provided an important service to the members of the Committee on the Mathematical Sciences in the Year 2000 and to the mathematical sciences community by making these data available in a convenient and accessible format.

The Executive Summary of *A Challenge of Numbers* was prepared by Bernard L. Madison, not as a condensation of the full report, but as a narrative document that focuses on some of the important issues that arise from the data. Information in this summary is excerpted, without references, in order to highlight the issues. The reader is asked to refer to the full report for specific sources and for complete sets of data.

WE Kirwan

William E. Kirwan
Chairman, Committee on the Mathematical Sciences
in the Year 2000
President, University of Maryland at College Park

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Executive Summary

Mathematics has long been recognized for fundamental contributions to advances in science and technology and as intrinsic to the education of people who will work in scientifically oriented occupations. In recent years the applications of mathematics have become more numerous, direct, complex, and essential in many jobs, as well as in everyday life. The increasing use of mathematics in the workplace has produced the need for more workers with a knowledge of college-level mathematics. At the same time demographic trends point to serious shortfalls of mathematically prepared workers and qualified school and collegiate faculty members to train them. The growing need for mathematical

Unless positive steps are taken now, the nation's needs for mathematically skilled workers will not be met.

skills and the effects of pressures on college and university mathematical sciences¹ over the past three decades have led many educators and policymakers to conclude that the current system is not responding effectively. Thus unless changes occur, the nation's needs for mathematically skilled teachers, scientists, engineers, and hosts of other workers for business, industry, and government will not be met. *A Challenge of Numbers* chronicles the conflict between projected need and projected supply.

¹ Most people accept the meaning of mathematical sciences as mathematics, applied mathematics, and statistics. That meaning is suitable for reading this report, but a broader definition is generally used in the taxonomy of scientific disciplines. Although computer science has in the past been considered part of the mathematical sciences, that is no longer the case.

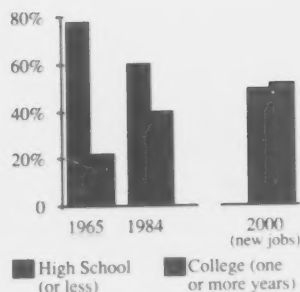


FIGURE 1. The educational requirements of the work force are increasing.

By the year 2000, the U.S. economy is expected to create more than 21 million new jobs, most of which will require both postsecondary education and the use of mathematics (Figure 1). Adaptability, problem-solving ability, and numerical reasoning will be critical skills. Eight of the ten fastest growing jobs will be science-based occupations by 1995. Educating sufficient numbers of workers for these occupations will strain the U.S. educational system.

The projected increase in demand for all scientists, engineers, and technicians between 1986 and 2000 is 36%, nearly twice the increase projected for overall employment demands. Many of the fastest growing fields will require workers with extensive mathematical backgrounds.

While the need for technologically trained workers is increasing, the prospective supply is shrinking. The college-age population is shrinking; by 1995 it will be about 22% below its peak in 1981. The problem is more acute in that white males now dominate the science and engineering work force, but their numbers will decrease by 34% for the college-age group over the same period.

Blacks and Hispanics, both growing portions of the college-bound population, have participated to a lesser degree in mathematics-based areas than have their white male peers. Meeting the increasing need with fewer students and also a greater proportion who have shown a lower interest in mathematics poses a major challenge to the nation's educational system, particularly to the mathematical sciences component.

The mathematical sciences, like other disciplines, experienced an increase in degree production at all levels during the 1960s, which was followed by a decrease in the 1970s. However, in comparison with other disciplines, recovery during the 1980s has been slow. Current trends do not project the recovery to be sufficient to meet expected demands for mathematically skilled workers in the future.

At a time when the precollege educational system is in need of revitalization and revolutionary change, our colleges and universities are not producing school mathematics teachers in sufficient numbers to meet current demands.

The most striking challenge is the one faced by the profession to educate itself and to renew its human resources. The current level of Ph.D. production in the mathematical sciences is not sufficient to respond to the future need to replace the now aging faculty. The situation is made more acute by the instability created by the large number of Ph.D. degrees received by non-U.S. citizens.

A Challenge of Numbers focuses on students and teachers—who they are, what they learn and teach, how they use what they learn, and the system in which they work. That system is vast and diverse. The mathematical

sciences faculty in the 2,500 U.S. colleges and universities constitute about 5.5% of the total collegiate faculty, but they are responsible for nearly 10% of all collegiate teaching and nearly 30% of all collegiate teaching in the natural sciences and engineering. Yet less than 1% of the 3 million students they teach are mathematics majors. This report concerns all students who study mathematics, not just mathematics majors. The majors, however, have a double role to play, as products of the system and, more importantly, as the source of the teachers and researchers necessary to renew and sustain the system.

High School to College: A Difficult Transition

The variations in background and motivation among beginning college students are greater in mathematics than in any other discipline. Initial placement in college mathematics courses is complex and difficult because many institutions have more than a half-dozen entry courses, ranging from arithmetic through calculus. The best entering students are excellent; the weakest have difficulty with elementary arithmetic. The transition from high school to college mathematics is one of the most troublesome in education. The difficult transition contributes significantly to attrition from the general education pipeline and especially to the attrition from the science and engineering pipeline.

Enrollment patterns indicate that most entering students are not mathematically prepared for college-level courses. Colleges have adapted by offering more elementary courses but have been generally unsuccessful in

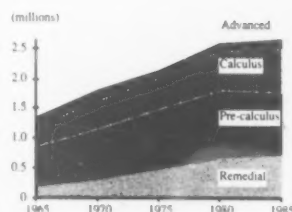


FIGURE 2. Total undergraduate enrollments in mathematical sciences departments.

The best entering college students are excellent; the weakest have difficulty with elementary arithmetic.

preparing students for advanced mathematics courses. Over the past 20 years, collegiate mathematics enrollments have doubled, but the major increases have been in the lower-level courses, those below calculus (Figure 2). Enrollments in remedial courses—high-school-level courses in arithmetic, algebra, and geometry—have led the way, tripling since 1965. Approximately two-thirds of college mathematics course enrollments are in courses below the level of calculus, that is, in courses similar to those taught in high school.

Improving precollege mathematics education will be hampered by a continuing shortage of qualified teachers. Shortages exist and are projected

to worsen, but definitive information about this critical work force is scarce. At the time when interest in mathematics as a major was falling, so also was the interest in education as a career. This double decline has drastically

Shortages of qualified school mathematics teachers will hamper improvements in precollege mathematics education.

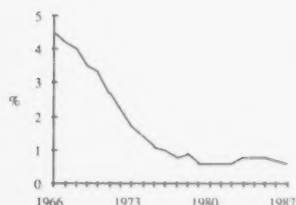


FIGURE 3. Percentage of entering college students expecting to major in mathematics.

reduced the number of college students preparing for school mathematics teaching. In the past few years both declines seem to have abated, but current trends indicate supplies far below those required to provide quality education at the precollege level.

Declining Numbers of Degrees Awarded

The popularity of mathematics as an undergraduate major has declined dramatically in the past 20 years. The numbers of U.S. students receiving bachelor's, master's, and doctoral degrees in the mathematical sciences were lower in 1986 than they were in 1966. And college enrollments approximately doubled during that period. Part of the decline is likely due to students choosing other mathematically oriented areas, particularly computer science; and part of the decline may be due to the shift of interest away from science and engineering. The decline in interest has been present at all points of the educational pipeline from the ninth grade onward but is most vividly displayed in the fraction of entering

The fraction of non-U.S. students in mathematical sciences graduate programs has risen from one-fifth in the early 1970s to nearly one-half at the close of the 1980s.

college students expecting to major in mathematics, now about one-sixth of what it was in the mid-1960s (Figure 3).

Paralleling those for other areas of science and engineering, the numbers of mathematical sciences bachelor's, master's, and doctoral degrees awarded annually increased steeply during the 1960s, decreased during the 1970s, and recovered somewhat during the 1980s. But the recovery in mathematics

has been the slowest of all. For example, in 1975 the number of mathematics doctorates awarded was 65% of the number of chemistry doctorates awarded. By 1985 this figure had dropped to 37%. Mathematical sciences degree production is now at about the levels of the mid-1960s—about 15,000 bachelor's, 3,000 master's, and 800 doctorates each year—levels generally considered too low to meet the demands of the near future (Figure 4). The recovery at the baccalaureate level in recent years is apparently due to students switching to the study of mathematics after entering college. This switching and similar patterns of changes in the numbers of degrees awarded at the three levels imply that undergraduate and graduate programs are tightly interconnected and simultaneously subject to the same forces.

Graduate programs in U.S. universities now depend heavily on non-U.S. students. The fraction of non-U.S. students in mathematical sciences graduate programs has risen from one-fifth in the early 1970s to nearly one-half at the close of the 1980s (Figure 5). This large influx of non-U.S. students into both master's and doctoral programs has not been enough to compensate for the very small number of U.S. students proceeding from one degree level to the next.

Participation of Minorities and Women

The number of students obtaining advanced degrees is lower for the mathematical sciences than among all the other sciences, indicative of the high attrition of U.S. students from the mathematical sciences pipeline. From entry into the ninth grade through receipt of the doctoral degree, a reduction by one-half per year of the number of students enrolled gives curiously accurate estimates of the numbers of students proceeding toward degrees. Thus an enrollment of about 3.6 million ninth graders diminishes to only about 400 U.S. doctorates awarded 14 years later, although this decline is probably not uniform from year to year and is definitely not uniform in its impact on various subgroups.

At all levels, relatively few blacks and Hispanics study or practice mathematics. Their attrition from the mathematics-based careers pipeline is higher than that for all students at all points, and that attrition is severe in the transition from high school to college mathematics. Longitudinal studies of students in the natural sciences and engineering pipeline have shown losses of three of four blacks and seven of eight Hispanics between the twelfth grade and the second year of college as compared to an overall rate of two of three.

The share of women in the mathematical sciences is also not reflective of their share of the U.S. population, but the pattern is different from that for blacks and Hispanics. In recent years, at the undergraduate level, the

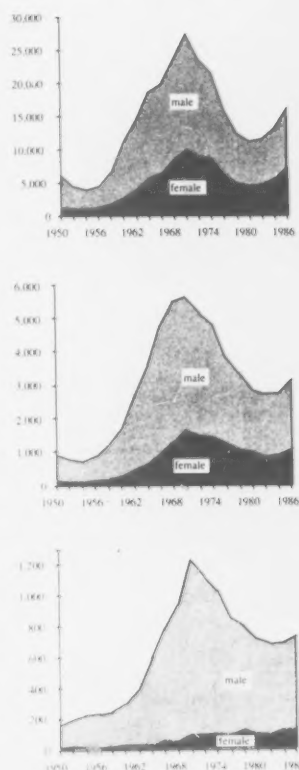


FIGURE 4. Number of mathematical sciences degrees awarded by U.S. institutions, 1950 to 1986. Top: bachelor's degrees. Middle: master's degrees. Bottom: doctoral degrees.

participation of women in the study of mathematics has improved significantly. For example, men and women are now receiving bachelor's degrees in mathematics in nearly equal numbers. But the percentage of women

Nearly four-fifths of the U.S. citizens earning new doctorates are either white males or Asian-Americans.

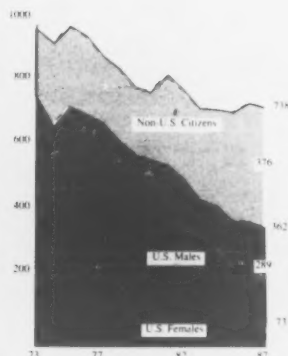


FIGURE 5. Ph.D. degrees awarded in mathematics.

receiving degrees falls off at the master's level, and dramatically so at the doctoral level.

The numbers of women, blacks, and Hispanics who receive mathematical sciences doctorates are very low. Nearly four-fifths of the U.S. citizens who earn new doctorates are either white males or Asian-Americans, and these two groups constitute only about two-fifths of the U.S. population (Figure 6). This and the fact that within 20 years, blacks and Hispanics together will constitute 30% of the traditional college-age population, indicate that unless positive steps are taken even fewer students will study mathematics at all levels.

Increasing Opportunities in the Workplace

Although mathematics long has been the underpinning of science and technology, mathematics has not been widely recognized as a profession except in academe; applied mathematics and statistics have somewhat wider recognition. All three classifications are becoming more visible in the workplace. Official labor data as reported by the NSF show that the number of persons employed as mathematical scientists has almost tripled in the past decade, and these counts do not include most mathematics teachers. Further, over the same period, the demand for employment of mathematical scientists in science and engineering areas has increased dramatically, so that now four of five nonacademic mathematical

The number of persons employed as mathematical scientists has almost tripled in the past decade.

scientists work in science and engineering (Figure 7). For the period 1986 to 2000, the projected increase in demand for mathematical scientists is 29%, compared to a 19% overall increase in employment demands.

Even though nonacademic mathematical sciences employment has increased, educational institutions are still a principal employer, especially for doctorate mathematicians, creating a close tie between the health of the mathematical sciences and the health of education. Demands for school mathematics teachers and for college mathematics faculty members have been high and are expected to increase over the next several years. Overall, approximately one-fourth of bachelor's degree holders, one-third of master's degree holders, and three-fourths of doctoral degree holders in the mathematical sciences begin work in education.

Over the past 40 years, approximately 525,000 persons have received U.S. bachelor's degrees, 110,000 have received master's degrees, and 24,000 have received doctorates in the mathematical sciences, but official counts of employed mathematical scientists include only about one-fourth of the total of 525,000. Many of these degree holders are employed in a variety of areas throughout the work force, and detailed information about current or future needs for replacements is not available. Outside academe, lack of information about what degree holders do now and what their potential contributions are dulls the appeal of mathematics as a major and as a profession. Within academe, mathematical scientists in the workplace are more visible, since mathematical science departments usually have a strong presence on campus.

Uncertain Stability and Renewal of the Faculty

The need for mathematical sciences programs to accommodate students from more diverse backgrounds and to educate more people to higher levels of proficiency has been met with a mixture of faculties and methods of teaching. The number of part-time faculty members has soared, tripling from 1970 to 1985 and accounting for the majority of persons on the faculty in two-year colleges. Part-time faculty members, graduate teaching assistants, and temporary full-time faculty members constitute approximately one-fourth of the full-time equivalents on the nation's collegiate mathematics faculty and carry a large share of the teaching in many departments. Especially during the 1970s, student enrollments increased significantly, while the number of full-time faculty members remained flat. Student-faculty ratios increased, especially in the research universities, where the number of full-time faculty members actually decreased by 14% from 1970 to 1985. The nature of teaching, the management of departments, and the role of traditional scholarship have all changed with these changes in types of faculty members and their duties.

The employment market for the full-time collegiate mathematical sciences faculty members is not very responsive to the usual laws of supply and

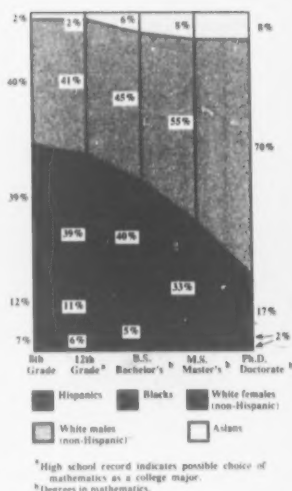


FIGURE 6. A representation of U.S. students in the mathematics pipeline.

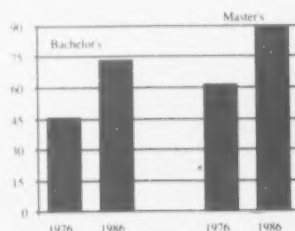


FIGURE 7. Percent of recent mathematics degree holders employed in a science or engineering job, 1976 and 1986.

demand. This faculty has few members—about 25,000—but their responsibilities are critical to the nation's efforts in science and engineering. There is no significant reserve supply of fully qualified candidates for faculty positions. Balancing supply and demand is difficult because of long

By the year 2000, the current number of new doctoral degree holders taking academic positions in the United States will not even be sufficient to replace faculty lost to retirement. And this assumes continued heavy reliance on non-U.S. citizens.

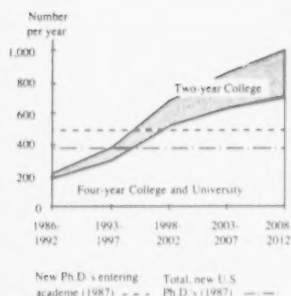


FIGURE 8. Estimated number of retirements of full-time college and university mathematical sciences faculty.

response times. There have been mild shortages of faculty candidates since the early 1980s and more severe shortages are likely by the year 2000. By then, the current number of new doctoral degree holders taking academic positions in the United States will not even be sufficient to replace faculty lost to retirement, much less to replace those that leave academe or to accommodate any increased demand (Figure 8). All this means continued heavy reliance on non-U.S. citizens. Almost all scenarios for reform of mathematics education would certainly exacerbate these shortages, and the likely increased demand for bachelor's and master's degree holders in business and industry will, at least in the short run, further increase the demand for faculty while simultaneously reducing the supply.

The U.S. mathematical sciences research community is the strongest in the world, and the graduate education of the best students is excellent. But there are signs of stress and weakening. Of full-time faculty members, about one-third are considered to be active researchers. Many of the remaining

The U.S. mathematical sciences research community is the strongest in the world, but there are signs of stress and weakening.

two-thirds have no program of scholarly renewal, which creates a greater likelihood of losing intellectual growth and enthusiasm as time goes by. Research in mathematics is traditionally defined as producing new mathematical results for publication in journals. This definition and the lack of alternative activities that are present in more applied areas have contributed to both the small fraction of faculty members considered to have active programs of scholarship and the gap between scholarly work and classroom lectures.

The Need for Renewal

In recent decades, new areas of mathematical sciences have grown and flourished, including operations research, discrete mathematics, mathematical biology, statistical design and analysis, and nonlinear dynamical systems. In fact, the term "mathematical sciences" itself has become a part of the taxonomy of science. In spite of these new developments, new applications, and new opportunities for using technological advancements, the teaching of mathematics has responded little. Both curricular content and its delivery have been slow to change. Mathematical sciences departments have not been able to simultaneously cope with enormous instructional loads, maintain excellence in faculty scholarship, and allocate resources to innovations. The forces at work are too diverse and too disparate.

By the early 1980s the need for renewal became clear, and the mathematical sciences community began to address the problems. In 1984 the National Research Council (NRC) issued *Renewing U.S. Mathematics: Critical Resource for the Future* (referred to as the David Report; National Academy Press, Washington, D.C.), documenting the erosion of federal

The MS 2000 project is an effort to assess the state of college and university mathematical sciences and to design a national agenda for revitalization and renewal.

support for research in the mathematical sciences. This was the first of a series of efforts within the NRC and in professional societies to assess the health of the mathematical sciences and to design a plan for renewal.

The NRC project Mathematical Sciences in the Year 2000 (MS 2000), of which this report is a part, was initiated in 1986 as an effort to assess the state of college and university mathematics and to design a national agenda for revitalization and renewal. As a major first step, *Everybody Counts* (National Academy Press, Washington, D.C., 1989), produced by the MS 2000 Committee together with the Mathematical Sciences Education Board and the Board on Mathematical Sciences, outlined the issues concerning mathematics education at all levels. *A Challenge of Numbers*, the first descriptive report of the MS 2000 Committee, provides a profile of the people associated with college and university mathematical sciences. Two additional descriptive reports are forthcoming, one on curriculum and one on support resources. These three reports will form a basis for the final report of the MS 2000 Committee, which will contain recommendations for actions to achieve revitalization and renewal of the mathematical sciences in colleges and universities.

Issues and Implications

The challenge of numbers emerges from two general facts: (1) the workplace has changed because jobs increasingly require higher-level skills and greater adaptability, and mathematics-based jobs are leading the way in increased demand; and (2) if current patterns persist, most socioeconomic and demographic trends indicate that fewer students will study mathematics and choose mathematics-based careers. These trends point to an increased demand for and a shrinking supply of mathematical scientists and other mathematically educated workers.

This dilemma poses a major challenge for U.S. education in general and college and university mathematical sciences in particular. Educating workers for business and industry and teachers for all levels of education may require fundamental changes in a system already stressed by the events of the past three decades. Several issues that require the nation's attention are apparent. These are raised by the following questions:

- **How can national needs for mathematically educated workers be met?** How can the expected shortage of mathematically trained workers be averted? How can available workers be better utilized? What incentives will attract more interest in mathematics-based occupations, especially among women, blacks, and Hispanics?
- **What changes are necessary to attract more students to the study of mathematics?** How can the mathematical sciences respond to the change in the traditional pool of U.S. college students? What and who will stimulate students to study the mathematical sciences? How can the heavy dependence on white males be reduced? What are the consequences of heavy dependence on non-U.S. students in graduate programs? How can teaching become more effective and stimulating?
- **What can be done to improve the success rate of students during the transition from high school mathematics to college mathematics?** How can high school preparation and college expectations be better reconciled? What effects are remedial programs and overlaps between the content of high school courses and college courses having on student attrition?
- **What can colleges and universities do to meet the national need for school mathematics teachers?** What is the appropriate education for secondary school mathematics teachers and for elementary school teachers? How can the college and university faculty assist in implementing new standards for school mathematics? What program of continuing education will enhance school mathematics instruction?

● **What actions will spur renewal and revitalization of the mathematical sciences faculty?** What steps should be taken to ensure replacements for the aging collegiate faculty? What is appropriate preparation for collegiate teaching? What continuing program of scholarship for the nonresearch faculty is necessary to maintain the intellectual vitality of the profession? How can better compensation, incentives, and working conditions be achieved and maintained? What is necessary to maintain and enhance the research production of the faculty?

● **How can better monitoring of the mathematical sciences be implemented?** How can both professional organizations and government agencies cooperate in the collection and reporting of information? How can data be collected, organized, and disaggregated to provide a comprehensive view of the mathematical sciences community? How can mathematical scientists be identified in the nonacademic workplace?

● **How can colleges and universities prepare graduates who are more valuable and effective in the nonacademic workplace?** What changes would make mathematics graduates more valuable to business and industry? How can the full potential of the contributions of mathematical scientists be explored? What new educational programs could diversify the employment opportunities for mathematical scientists? Are there unrecognized opportunities for Ph.D.s in the mathematical sciences?

These issues center on the mathematical sciences enterprise in U.S. colleges and universities, but they have implications for all of society. In order to ensure a healthy flow of mathematical talent, a flow required to feed a technological society, this challenge of numbers must be met.

Figure Credits

FIGURE 1 The educational requirements of the work force are increasing. *Handbook of Labor Statistics*. Bureau of Labor Statistics, U.S. Department of Labor, Bulletin 2217, Washington, D.C., June, 1983, pp. 164-171. *Workforce 2000—Work and Workers for the 21st Century*. Johnston, William B., and Packer, Arnold E., Hudson Institute, Indianapolis, Indiana, June, 1987.

FIGURE 2 Total undergraduate enrollments in mathematical sciences departments. *Undergraduate Programs in the Mathematical and Computer Sciences: The 1985-86 Survey*. Albers, Donald J., Anderson, Richard D., and Loftsgaarden, Don O., The Mathematical Association of America, MAA Notes, Number 7, Washington, D.C., 1987.

FIGURE 3 Percentage of entering college students expecting to major in mathematics. *The American Freshman: Twenty Year Trends*. Astin, Alexander W., Green, Kenneth C., and Korn, William S., Cooperative Institutional Research Program, American Council on Education, University of California, Los Angeles, 1987.

FIGURE 4 Number of mathematical sciences degrees awarded by U.S. institutions, 1950 to 1986. *Digest of Education Statistics, 1988*. Snyder, Thomas D., National Center for Education Statistics, U.S. Department of Education, Washington, D.C., 1988.

FIGURE 5 Ph.D. degrees awarded in mathematics. Annual AMS Survey Reports 1976 to 1986, *Notices of the American Mathematical Society*, American Mathematical Society. Annual AMS-MAA Survey Reports 1987 to 1988, *Notices of the American Mathematical Society*, American Mathematical Society. Various Authors.

FIGURE 6 A representation of U.S. students in the mathematics pipeline. Annual AMS Survey Reports 1976 to 1986, *Notices of the American Mathematical Society*, American Mathematical Society. Annual AMS-MAA Survey Reports 1987 to 1988, *Notices of the American Mathematical Society*, American Mathematical Society. Various Authors. *Preliminary Estimates of the Population of the United States, by Age, Sex, and Race: 1970 to 1981*. Current Population Reports, Series P-25, No. 917, Bureau of the Census, Washington, D.C., 1982. *Projections of the Hispanic Population: 1983 to 2080*. Current Population Reports, Series P-25, No. 995, Bureau of the Census, Washington, D.C., 1986. *Digest of Education Statistics, 1987*. Snyder, Thomas D., National Center for Education Statistics, U.S. Department of Education, Washington, D.C., 1987.

FIGURE 7 Percent of recent mathematics degree holders employed in a science or engineering job, 1976 and 1986. *Science & Engineering Indicators—1987*. NSB, National Science Foundation, Washington, D.C., 1987.

FIGURE 8 Estimated number of retirements of full-time college and university mathematical sciences faculty. Annual AMS Survey Reports 1976 to 1986, *Notices of the American Mathematical Society*, American Mathematical Society. Annual AMS-MAA Survey Reports 1987 to 1988, *Notices of the American Mathematical Society*, American Mathematical Society. Various Authors. *Undergraduate Programs in the Mathematical and Computer Sciences: The 1985-86 Survey*. Albers, Donald J., Anderson, Richard D., and Loftsgaarden, Don O., The Mathematical Association of America, MAA Notes, Number 7, Washington, D.C., 1987.

Mr. BROWN. Thank you very much, Doctor Griffiths.

Ms. SCHNEIDER, do you have any questions?

Ms. SCHNEIDER. Well, Mr. Chairman, I think that the testimony was very straight forward and, quite frankly, I don't have any questions.

Mr. BROWN. Well, keep thinking.

Ms. SCHNEIDER. As you were, too.

Well, I can ask a question of Doctor Schambra. In reference to the meager numbers of scientists or the numbers of people that we are attracting into the biological sciences, I believe you said that merely one-fourth of the people who are currently pursuing biological sciences are foreign nationals. Was that the figure that you gave?

Dr. SCHAMBRA. That's correct. Of about 40,000 graduate students in the biological sciences, we estimate that approximately one-quarter are foreign nationals, which is probably a lower percentage than in some other fields, like mathematics and engineering to be sure.

Ms. SCHNEIDER. Are there any particular incentives that you offer the foreign nationals in the areas of research that may not be offered broadly to all scientists? Is there any targeting that is being done?

Dr. SCHAMBRA. Not specifically in the academic community. I would say that there is a spill-over effect by virtue of the long-term investment which the Congress and the public have made in support of biomedical research over the years. That has led to a very large and a very successful, obviously on a world basis, biomedical research enterprise which has attracted a very large number of foreign scientists. It is a very large enterprise.

Ms. SCHNEIDER. I don't have any further questions, Mr. Chairman. I regret that I must leave; I have a markup in another committee, but I know that you will carry on.

Thank you.

Mr. BROWN. It is unforgivable, but we'll have to accept it, I guess.

Doctor Schambra and Doctor Willenbrock, obviously this is an area which is of considerable policy importance to the future of our scientific and technological enterprise. Has the Administration developed a coordinated position reflecting these concerns for presentation to the Committee on the Judiciary, which has jurisdiction over immigration?

Dr. SCHAMBRA. I would turn to our mutual General Counsel here.

Dr. WILLENBROCK. As we have appointed Mr. Herz our mutual General Counsel, if you don't mind, we will refer that question to him.

Mr. HERZ. Mr. Chairman, the Administration has formulated, as you may be aware, an overall position on the pending immigration legislation and has some considerable difficulties with H.R. 4300 as it emerged from the subcommittee markup. However, I don't believe those difficulties are primarily focused on the issues that your committee is focused on this morning, because I believe there is agreement, and certainly the Administration favors increased overall ceilings for permanent immigration. In general, it also favors the switch to more skill-based immigration as opposed to family-

based immigration, and finally, it is particularly aware of the problems and the opportunities that the Nation has in the area of immigration of scientists and engineers. I think it is fair to report that in the internal counsels of the Administration there has been much friendliness to the notion that we need to do something to improve the ease with which we can obtain and retain scientific and technical talent in the United States.

One area in which the Administration I would say is friendly but where the formal position of the Administration at this time is that it is too early to discuss the issue is the area of non-permanent immigration. The view is that the present legislation should focus on permanent immigration, which is a big enough bite to chew off at the moment; not that there is an indisposition, however, to change in the non-permanent immigration.

Mr. BROWN. Well, of course, it is my view and has been for a long time that we need to have some system for developing coordinated policy in the areas of science and technology which can be used as a basis for action by the Administration and the Congress. My question was intended to elicit how far we have progressed in that direction in this particular component of science and technology policy. Now there is a difference between being friendly to and having a policy. I don't want to belabor the point, but in the testimony presented this morning there have been some very significant suggestions from Doctor Griffiths and others as to how to improve this situation. If it is really an important issue of national policy, I think it should be reflected and a position taken by the Administration, and particularly by the Science Advisor who is charged with that responsibility. If you could convey that information to him, I would appreciate it.

Mr. HERZ. We will do so, Sir.

Mr. BROWN. Doctor Schambra, NIH is having not only difficulties relating to the vast range and complexity of the scientific problem it addresses, but it has a few problems in funding scientific research, including the number of new grants it is able to make. You have cogently set forth the need for additional scientists in the biological fields, yet you are making a declining number of grants. Is there something wrong with the policy approach here or is it all the Congress' fault?

Dr. SCHAMBRA. No, Sir, I wouldn't say that, but we do hope that things will look up in that regard in the future. Of course, we are looking down the path some four to ten years. What we are looking at is an impact which is going to show up increasingly in the years ahead and remaining part of this decade. Although the early signs of the shortages of manpower are showing up right now in terms of the number of young scientists who are applying for NIH research grants and even the difficulties in recruiting scientists into the intramural research programs at NIH.

Mr. BROWN. Doctor Schambra, as I read the lay scientific press, it is replete with pleas from scientific societies—biophysicists, various other groups—complaining about the lack of funding for young scientists. Of course, it was the NIH which decided, and was encouraged by the Congress, to make larger grants for longer periods of time, which, of course, drastically reduced the amount of money you had available for funding young scientists. Somebody

must have overlooked the fact that you can't have it both ways. In other words, is there an indication that we may not have engaged in sufficiently adequate strategic planning, which basically means planning for five years or more down the pike?

Dr. SCHAMBRA. I think to be sure there is some indication of that. It is clear that we were trying to be responsive to the scientific and academic communities by making these grant awards for longer periods of time so that scientists one year into their grant wouldn't already have to be applying for renewal of that grant even before they had developed significant research results. But that does have longer term implications in terms of the out year commitments. That is a difficulty we are facing right now and, of course, are fully engaged with the appropriations committees on both sides in seeking a resolution of that situation.

Mr. BROWN. The appropriations committees, as you know, have a long history going back many years of adding to the Administration's budget request for NIH. In the light of this, it seems anomalous for the scientific community to complain about the harsh treatment they are getting from the Congress. It also seems anomalous that at a period when we need more biological scientists we are able to train fewer. We have got to resolve these anomalies in some way.

The Congress, even though it may be extremely generous to the NIH budget, is going to look at 25 years of increases in that budget and say that it has reached maturity and that they can't understand the justification for large additional increases, even though they may grant say a 5 percent or a 10 percent increase. Can you make a case for a substantial increase in the funding for biological research at this point? And, if you can, have you?

Dr. SCHAMBRA. Well, that is a burden that is probably much larger than my shoulders would be able to carry, Mr. Chairman. I think that it certainly ties in with the larger issue of national investment in the scientific and technical enterprise of this country and whether we want to stay in the relative superior position that we are in now in the entire world enterprise. I think that as a result of the long-term investment which the Congress and the public have made in the biomedical research, we have seen major advances in a number of disease areas; we have created the whole industry of biotechnology; that the spin-offs into the commercial sector are going to be very significant. I think it is very instructive that the NIH role in the national biomedical research enterprise has fractionally, has disproportionately declined over the past decade or so from a point where we were the majority—maybe two-thirds to three-quarters—of the national investment point to where today we are maybe one-third of the national investment. This over the same period of time in which the NIH budget has doubled in absolute terms. The difference, of course, is the investment that industry if making and other elements of the private sector and other Federal agencies. I think that if we want to continue to be superior in the world and continue to benefit both health-wise and commercially, that does suggest that we should continue to invest in and to see this sector of our national enterprise grow.

Mr. BROWN. You are making a good start, Doctor Schambra, but I don't think it is good enough. The fact is that the total invest-

ment by this country in all forms of civilian R&D is less today than it was 25 years ago in terms of percentage of the GNP. All of our competitors have doubled in that period of time. That is the reason that we are in the mess that we are in today. If the scientific community can't make that case, you can't expect us poor congressmen to make it.

Dr. SCHAMBRA. Point well taken.

Mr. BROWN. I welcome any questions you might have, Mr. Boehlert.

Mr. BOEHLERT. I have the questions; I don't have the answers.

Doctor Griffiths, it seems to me that those who provide the forecast for the year 2010 are conceding failure on our part and I am not willing to do that. For example, your testimony says that it has been estimated that in 2010 we are going to have 60,000 more engineering jobs than we will have people to fill them. That's an ominous threat. We are talking about the children entering the school system this fall, they will be the graduate engineers in the year 2010. We have to start at the beginning. What should we be doing differently right at the beginning to encourage the young people of America to get excited about science and math disciplines?

Dr. GRIFFITHS. I believe that our current shortage of scientists and engineers reflects a crisis in science education, in the public perception of the status of scientists and engineers, and in the Federal support of basic research which must be addressed. Together, the scientific community and the Federal Government need to work for the long-term solution of the manpower shortage.

Scientists and engineers in colleges and universities and national laboratories and in industry need to reach into grades K through 12 to make science and engineering real and interesting and to sustain students' early enthusiasm for science and mathematics. The process of scientific discovery is fun and exciting. This sense of excitement must be communicated to our youth; but all too often it is lost in the grind of facts and figures. At colleges and universities and in continuing cooperation with organizations such as NSF and the National Academy of Sciences we need to radically reassess our curricula from pre-school through the baccalaureate. Even at our top research universities, where often rewards are based on research accomplishments, new structures for properly recognizing and rewarding pedagogy should be instituted.

I think these projections can be reversed, but they are going to require really the scientific community and the Federal agencies to work in a different kind of partnership than has been the case in the recent past.

Mr. BOEHLERT. All right. Do you have any outline of the type of partnership that you would envision? For example, it disturbs me that a very high percentage of young people in America's public education system are being taught science by teachers who were not science majors in college, who are not certified science instructors. I think American industry, quite frankly, has taken a walk in its responsibility. It bemoans the fact that we don't have coming out of our school system what we need, but I don't see American industry sending some of their talent into the school system to supplement what is being taught. I am wondering what is our role?

How can we encourage that? How can we promote it? Do you have any thoughts on that, or any of the panelists?

Dr. GRIFFITHS. In the State of North Carolina the Governor has an Advisory Committee on Science and Technology which has members from the private sector on that committee. In recent years they themselves have begun to see the responsibility that the private sector has to address the crisis in science education. They have actually begun to send scientists from pharmaceuticals, from chemical plants, things like that into the schools.

Mr. BOEHLERT. Are they having any problems with the teachers unions, for example?

Dr. GRIFFITHS. I can only speak for the State of North Carolina. I don't believe that this is an issue in North Carolina.

Dr. WILLENBROCK. If I may add to Doctor Griffiths' comments. I would say that there is a very major concern about changing the attitude of the U.S. students towards science, engineering, and mathematics. I think that there is a major effort being made within the National Science Foundation where we have reorganized our education and human resources activities; and also there is a major effort to get a cross-cutting operation among the Federal agencies in this area. The Federal Coordinating Council for Science, Engineering, and Technology has a committee set up that is working very hard on doing exactly that. So, there is a major effort to confront these issues. I think they are being stated very starkly in figures you have seen and we are well aware of them. We anticipate that there will be major requests to the Congress on helping out in this respect.

Mr. BOEHLERT. I want to carry this a little bit farther. In reading the newspaper every morning, I must confess that the first thing I turn to is the sports page because the previous 24 hours in Washington, D.C. have exposed me to the problems of the savings and loan crisis and the budget summit and all these other things; I want some relief. If I look at the sports pages or if I look at the New York Times Sunday Magazine or all these other publications that I read ad nauseam, I see all these ads for these sport camps, for example, for a young kid that wants to be a baseball player and make \$2 million someday or a basketball player. But I am wondering should NSF, for example, have science camps? Should industry have science camps for young kids at a very early age to come to some pleasant setting and you get all their juices flowing and excited about the wonders of science? We have got to do a better job of stimulating interest at an early age. Quite frankly, most of us as parents, it is way beyond our ability to do so. Agencies, the private sector, the university community—I mean, Duke University should have a science camp that they sponsor in concert with industry during the summer and grab these kids at a very early age; science fairs, all sorts of things like that. I am not willing to accept failure in the year 2010. I am not willing to say we are going to be 60,000 engineers short, or that we are going to be short in all these other disciplines. That says we are admitting failure and I am not willing to do so. So give me some of your thoughts on that.

Dr. WILLENBROCK. I thoroughly agree with you that intervention strategies is what we need. Frankly, we are looking at those intervention strategies because the predictions that Doctor Griffiths

made, if following current trends, that is where you are going to end up. I think that there are techniques and there have been success stories; a significant success stories, for example, in the Philadelphia region where they have had the Prime, the Prism, and a whole series of programs of that nature where they put together universities, industry, and the local government and have had very significant effects on, for example, minority students and their retention rates and that type of thing. So I think it can be done. I think it is going to take some vigorous action on our part, and I can assure you we are making a major effort in the National Science Foundation to do something about it.

Dr. SCHAMBRA. Mr. Boehlert, I might indicate for the record on behalf of NIH that we do have a number of programs of modest size aimed at young men and women at the high school level, including the Federal Junior Fellowship Program which provides summer and vacation on-the-job training, several programs aimed at needy youths and the minorities, a summer program in the neurosciences, and so on. So we are trying to make an effort along these lines.

Mr. BOEHLERT. That's great, but I would suggest that by that stage the dye is cast. The people you are appealing to with this program, they have made up their mind, you don't have to do much more convincing. I want to start even earlier than that.

Dr. GRIFFITHS. You suggested that Duke should do summer camps. In fact, we have three of them—one in mathematics, one in writing, and one called the Talent Identification Program, which is for talented youths beginning at 7th grade throughout the Southeast. This has been a very successful program. What limits it though is the expense of carrying it out successfully. The kids who come there have a very good track record; they go on to the North Carolina School of Science and Math and similar schools and—

Mr. BOEHLERT. What happens when you appeal to industry for some support for the program?

Dr. GRIFFITHS. We do, and industry supports this rather generously. Nonetheless, the constraining factor in bringing as many of these kids to the Duke Campus and getting our faculty involved in teaching them and so on is the financial burden the families would have to pay for their students.

Mr. BOEHLERT. I can appreciate that, believe me.

Dr. GRIFFITHS. I mean quality costs money.

Mr. BOEHLERT. I would like to pursue this further but the Chairman wants to move on. Thank you all very much.

Mr. BROWN. Mr. Boehlert has been pursuing very well the importance of changing educational strategies on the scientific and technical manpower problem. I was pursuing the fiscal or resource and long-range planning aspects. Now I will ask Mr. Skaggs what he wants to concentrate on.

Mr. SKAGGS. Thank you, Mr. Chairman.

I think any of us that represents areas with major research institutions hear from our friends on the science and engineering faculties bemoaning the situation that they foresee in a few years in which our ability to get the best people into those teaching jobs further erodes in competition with other careers in the private sector in particular. My understanding is that the reason we have been

able to attract as successfully as we have over the years immigrant science students, Ph.D. level or otherwise, has had a lot to do with the caliber of our faculties. So I wonder if the fears about what is going to be happening to the faculties are correct and well-founded, whether immigration law reform or not, whether we are really going to have the magnet that exists now to bring in the talent that we think we can get if only we didn't have legal impediments in the way? Anybody that would care to comment on that, I would appreciate it.

Dr. WILLENBROCK. If I may respond, I think your concern about the health and well-being of the science and engineering faculties of the country is well-placed. That is a major concern that we have at the Foundation and it is a major effort that we are making to ensure the health and well-being of the entire pipeline which ends up with faculty members. It is crucially important, in my estimation, to make sure that our universities retain their front rank on a global basis. I think we can do that if we continue some of the open policies that we have had; and that is why the immigration one is so serious, because we have attracted the best students and they, in turn, encourage and develop the best faculty members. I think if we keep that process going effectively, we are on the right track. I think that ought to be our basic strategy in this area.

Our own feeling here is that there is a concentrated need for support in working the entire education and human resources pipeline. We are very concerned about that. We think if we can improve that through various programs, we can then ensure that the faculty stays at the level it needs to be. The concern, of course, is the general support for research—which you have already discussed, particularly by Doctor Schambra, which also goes for other areas besides the biomedical one—but the investment in that entire enterprise, which is top quality on a global basis, I think needs to continue and needs to be strengthened.

Dr. SCHAMBRA. If I might just pick up a note from Mr. Brown, that underlying all of this will depend upon our continued and growing investment in the research enterprise of this country; that as long as we have a healthy research system, we are going to attract people from both at home and abroad to participate in that.

Mr. SKAGGS. Picking up a little bit on Mr. Boehlert's comments and questions, your testimony does seem to begin with a kind of static view of the proportion of American talent that we are likely to attract into science and engineering. That is not a given, it seems to me, and in particular—this is somewhat tongue in cheek—assuming that we succeed in achieving the President's and National Governor Association's goals of being first in science and math with our high school graduates by the end of the century, won't that take care of all the rest? That is implicit in having gotten to be number one again is an attraction of talent and interest and stimulus, and all the rest that will flow on into college and graduate level education and careers.

Dr. WILLENBROCK. I would like to suggest that the best strategy is not only getting number one in our own Nation and increasing our own indigenous capability, but also continuing to attract on a global basis the top students from around the world. That has been the formula we had immediately after World War II and I think it

was an extremely successful one. I hope we can continue that because that appears to be the formula for success in keeping our leadership and front rank position in all the sciences and engineering.

Mr. BOEHLERT. Would the gentleman yield?

Mr. SKAGGS. Certainly.

Mr. BOEHLERT. What are the trend lines? I mean, things are changing around the globe right now. It used to be that so many came here because we were the great mecca for opportunity, but now so many of these people are going to see opportunity right at home because the tidal wave of democracy is sweeping over the world. That is sort of a threat in an unusual way. What are the trend lines?

Dr. WILLENBROCK. I think the trends unfortunately are in the wrong direction as far our own students go both in science, mathematics, and engineering. That's why we are concerned about intervention strategies and ways to change that trend. So if we let them go the way they are going, we are not in very good shape.

Mr. BOEHLERT. No, no. What I am talking about is we have always attracted the best and the brightest of the foreign students who would come here and go all the way through and get their Ph.D.s and then would stay here because here was the land of opportunity. Now they see the opportunity back home, maybe in Hungary, Czechoslovakia, or who knows where. Are we beginning to see a reversal of the retention rate?

Dr. WILLENBROCK. We are seeing some increased emigration which I think is significant. As I have indicated in our testimony, we don't have hard data on that, we have anecdotal data. I happen to have visited both Korea and Taiwan recently where they are very actively repatriating some of their Ph.D.s in science, engineering, and mathematics. The situation though is that they still send their best students and some of their best students stay. So even though there is a repatriation process, it is not taking all of them back.

I would also point out that we have some unique advantages; one of the major ones being the English language. Eighty percent of the world's science and technology literature is in English, so if you want to study, do graduate work, coming to an English speaking country is the best place to go and the U.S. continues to attract the top students both from Taiwan and Korea. Some of them return but not all of them.

Mr. BOEHLERT. Okay. Thank you.

Mr. SKAGGS. My recollection is that in the period of the late 1950s and 1960s we were sending a relatively greater percentage of our young talent into science and engineering. If we were to resume that career path for folks coming of age in the next couple of decades, to what degree would that solve the anticipated shortfall that you all anticipate?

Dr. SCHAMBRA. I might say that I am sure that part of the present problem in the decline in the number of young men and women going into science and engineering fields is the decline in support from the Federal Government. Just to cite one statistic, during the last 20 years federally-supported fellowships and traineeships have declined from an annual rate of 60,000 to today less

than 14,000. I think that is bound to have had an impact in all fields.

Mr. SKAGGS. Doctor Griffiths?

Dr. GRIFFITHS. I think you all know better than I the experience that we had in the late 1950s and the 1960s in the post-Sputnik which shows that Federal support of education and research can certainly stimulate the retention of the talent that is there into science and engineering. My own assessment is that is part of the solution, and a necessary part of the solution, but coupled with that the scientific community itself needs to assume some of the responsibility for getting the message out that this is a great life; it is great fun doing science. I think kids naturally tend to be interested in science and something is going on in the educational process that is not working properly. We are beginning to have some understanding of that, at least in mathematics, but it is going to have to be thought through and pursued systematically for a number of years to reverse recent unfavorable trends.

Mr. SKAGGS. Perhaps one variation on the suggestion that Mr. Boehlert made is that we should have summer camps that are based on a bait and switch strategy; that would be advertised for lawyers and MBAs and once you got them there then you start to do science.

[Laughter.]

Mr. SKAGGS. Thank you, Mr. Chairman.

Mr. BROWN. Let me just ask one final question. Is there a difference between the various disciplines and subdisciplines as to the projected availability of trained manpower? For example, do we foresee shortages of mathematics and physicists and an excess of chemists or something like that? Sometimes the sub picture is significant here.

Dr. WILLENBROCK. I think perhaps the most significant decline has been in the mathematics area where it has gone way down. For a number of years they aggregated the data with computer scientists and mathematicians in the same category so that no one knew what was happening. I think there has been some major effort by the mathematical community to turn that around, which I think is very desirable, and that sort of thing ought to happen. There is a very strong interest these days in the biological sciences, and I don't want to imply that is inappropriate, but I do think we have to worry about some of the other areas, like physics, which has gone down pretty strongly. My own feeling is that we need to work on practically all those areas. But I wouldn't say that there is a very strong disproportionate number in any one area.

Mr. BROWN. Do you have anything to add to that, Doctor Schambra?

Dr. SCHAMBRA. I think that certainly looking into the remainder of the decade we can expect the biotechnology industry to continue to grow and to require more and more talented individuals in that enterprise. I think it is questionable whether we are going to come anywhere near to meet those demands under current projections.

Mr. BROWN. Thank you very much, gentlemen. I am trying to be disciplined as to time here and we just allotted you an hour, and you have just taken it. We thank you very much for your testimony.

Our next panel will include Mr. Ron Tekely, representing the National Foreign Trade Council with Westinghouse Electric Corporation; Doctor Martha Cotter, Executive Officer for Graduate Programs in Chemistry at Rutgers; and Doctor Stanford Penner, Professor of Engineering Physics at the University of California, San Diego.

Mr. Tekely, would you like to lead off?

STATEMENT OF RONALD A. TEKELY, CHAIRMAN OF THE IMMIGRATION COMMITTEE OF THE NATIONAL FOREIGN TRADE COUNCIL, INC., WESTINGHOUSE ELECTRIC CORPORATION, PITTSBURGH, PENNSYLVANIA

Mr. TEKELY. Thank you, Mr. Chairman.

Mr. Chairman and distinguished members of the committee, my name is Ronald Tekely, Chairman of the Immigration Committee of the National Foreign Trade Council. The National Foreign Trade Council is a non-profit association of 500 member companies in the United States involved in international trade and investment. Its members have long supported efforts to improve U.S. immigration policies and procedures.

We understand that the subcommittee is seeking to learn about the problems that U.S. immigration laws present to industry in employing foreign nationals. Many U.S. companies have been very concerned about the quality as well as the availability of suitable employees and have funded and participated in many programs to improve the overall situation.

U.S. companies look primarily to the U.S. workforce to fill these positions, but as we all know, there is a critical shortage of science and engineering graduates, especially with advanced degrees.

Australia and Canada, who allow about two-thirds of the world's total legal immigration, are far more successful at attracting talented immigrants than we are. This is primarily due to the fact that our legal immigration system favors family unification. Approximately 95 percent of the legal immigrants in 1987 were granted entry because they were related to a U.S. citizen or a resident, while only 4 percent were admitted for employment. It is obvious that our current immigration laws do not promote the immigration of highly skilled people, despite the shortages in certain occupations. We are not asking to take away from any other group; we merely want to keep our competitive edge in the world market.

To compete effectively in the global marketplace, U.S. companies need immigration laws that provide predictability in the planning of international movement of key personnel. They also need expeditious procedures that assure that personnel decisions can be implemented within reasonable time frames. Current immigration laws do not provide the needed flexibility and efficiency required when businesses make the difficult decision, with its attendant relocation costs, to bring key foreign employees to the United States.

In many important science and engineering fields, foreign employees have done some of the most innovative research which U.S. companies must have access to and take advantage of in order to continue to be competitive in an ever increasingly competitive world market. Foreign managers and marketing specialists can

bring to U.S. firms their unique knowledge of local marketing conditions and consumer preferences that can make the difference between success and failure in penetrating foreign markets.

Yet, with this in mind, our present legal immigration laws and policies are rooted in legislation enacted in 1952 and have failed to keep up with these evolving needs. As a result, U.S. companies that need the skills of international personnel confront a variety of disconcerting obstacles in a process characterized by inflexibility, delay, and an absence of predictability. The ability to have the right person with the best technical or managerial skills in place at the best possible moment can make the difference between a successful project undertaken ahead of the foreign competitors, and an also-ran position that might effectively close the U.S. company out of the market altogether.

The third preference visa petition filed in February of 1989 is only now, over 18 months later, being processed and the wait for the sixth preference is backlogged well over three years. This is obviously not acceptable and solutions are urgently needed now.

The shortage of scientific talent in the U.S. is of great concern to our member companies. One company said, "We have spent over \$1.4 billion on R&D in 1989 and we employ over 3,000 Ph.D.s in the United States alone. The backbone of our company is R&D which we need to maintain our competitive edge. If we are unable to staff these positions with U.S. citizens or foreign nationals, this would have a major detrimental impact on our global competitive position."

You have asked us to address several specific problems dealing with employing foreign nationals in the United States.

The first question is: Do the immigration laws prevent U.S. companies from using qualified immigrants for jobs in the United States?

The answer is yes. And the reason is simply that there are not enough employment related visas available under our current system. The long delays I referred to earlier are a direct result of the shortage of visas in the 3rd and 6th preferences. Companies cannot operate effectively with such long delays when they need to transfer an individual who is essential for the success of a particular business, product, or new technology.

Furthermore, it must be understood that the present system charges visas to spouses and children against already low quotas. We suggest an increase in the number of employer-sponsored visas from the current level of 54,000 to 150,000.

The second question: Do U.S. companies have difficulties in bringing foreign scientists and engineers to the U.S. on a temporary basis?

There are many problems. Although the new H visa regulations issued by the INS in February have helped somewhat, they have substantially increased the documentation requirements, and we still have the problem of working spouses of H employees who are not permitted to work in the United States with the derivative status they are given. As stated earlier, many companies use the H category to staff research activities in the U.S. and have difficulty doing so, but the present House immigration bill would place an annual cap on the number of H admissions and would subject these

jobs to a labor certification approval. Needless to say, our members are very opposed to a cap which would cause delays of several months at a time when the ability to move quickly to respond to current competitive issues is paramount.

We have major problems with the L-1 intracompany transferee category. Over the last ten years, the INS has drifted away from the original congressional intention of transferring key company personnel to the U.S., and have issued regulations that include very narrow and restrictive definitions of managers, executives, and specialized knowledge employees.

Third question: Does the labor certification process hinder our efforts to develop a qualified workforce in the U.S.?

The permanent labor certification process needs to be streamlined and made more efficient. Almost 90 percent of all applications filed are eventually approved, but this is accomplished only after a significant expenditure of time—up to a year in some regions—and at significant expense to both private companies and the taxpayers. U.S. companies and the Department of Labor would both benefit by the expansion of the occupations and positions listed in Schedule A after it has been demonstrated that a particular occupation is in short supply. This can be done on a regional basis within the current system. A provision that would require an occupation to be scheduled for say two years, once ten certifications in that occupation are issued within a region, would both shorten and reduce the expense involved.

The business community believes that the labor attestation process contained in the current House bill will, in practice, be worse than the current labor certification process, and recommend that it be removed from the bill.

The fourth question is: Does U.S. immigration law in any way affect what jobs companies place in the United States and what work they do overseas?

Highly skilled researchers are in short supply in the United States and companies are having difficulty dealing with the 18 months it now takes to get permanent employment authorization. A few companies are now considering moving their research facilities abroad in order to adequately staff their research projects. At least three member companies have already transferred their R&D activities to France, Germany, and the U.K. to maintain their competitive edge. There is also the danger that companies will scale down their R&D spending or delay R&D projects. One company said: "The shortage of scientific Ph.D.s is slowing down crucial R&D projects. Our company is definitely falling behind our foreign competitors."

You can appreciate the ramifications if this trend continues, and it underscores the need for more employment visas.

The fifth question concerns the point system. Would a point system, as proposed in S. 358, enable more scientists and engineers to receive visas?

As it currently exists, S. 358's point system would provide some minor benefits but it would not meet the specific job requirement needs of a company. An engineer might qualify, but he or she might not have the specific produce or market experience that is needed. We feel that employer-sponsored immigration by a specific

qualified immigrant for a specific job, after labor certification, is the best way to determine and fill actual shortages in the U.S. workforce. We do support experimentation with "new seed" immigrants, but suggest that more emphasis be placed on education, training, experience, and job skills.

The sixth question: One-half of the graduate students in many scientific and technological disciplines are foreign students. We are spending valuable resources to train them. To what extent do immigration laws impact on their remaining in the United States after graduation?

With the current 3rd preference backlog, it is virtually impossible to employ a graduating foreign student on a permanent basis in the United States. The only avenue is to employ the graduate on a temporary basis with an H visa, but this is only a temporary solution if the company wants the individual to remain in the United States for their entire career. In addition, many positions require Government security clearances and can only be filled by U.S. citizens. The time spent in the U.S. on an H visa can not be applied to the total time required to become a naturalized U.S. citizen. An increase in employment-related visas would help to improve the return on this investment.

In conclusion, the interest of U.S. companies, and the U.S. as a whole, will best be served by legal immigration reform that provides adequate attention and resources to employer-sponsored immigration. Reform must include increased allocation of permanent visas to employer-sponsored immigrants, with immigrant and non-immigrant revisions that better reflect business needs and priorities, a streamlined labor certification process with expansion of the schedule of precertified occupations in known job shortage fields, and a system that provides clear predictability and expeditious processing. Only if the U.S. moves forcefully to keep its competitive edge in the international marketplace will the economic well-being and long-term employment prospects of U.S. citizens be assured.

Thank you again for the opportunity to present the views of the National Foreign Trade Council on behalf of its members.

[The prepared statement of Mr. Tekely follows:]

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
Subcommittee on Science, Research and Technology
STATEMENT OF THE NATIONAL FOREIGN TRADE COUNCIL, INC.
July 31, 1990

Mr. Chairman and distinguished members of the Committee:

My name is Ronald A. Tekely, Chairman of the Immigration Committee of the National Foreign Trade Council, Inc. The Council is a non-profit Association of 500 member companies in the United States involved in international trade and investment. Its members have long supported efforts to improve U.S. immigration policies and procedures affecting the transfer and employment of foreign executives, managers and technical personnel - just as we have supported and encouraged the transfer of such personnel to conduct business in foreign countries.

We understand that the subcommittee is seeking to learn about the problems that U.S. immigration laws present to industry in employing foreign nationals. You are concerned about the long range solutions to problems of labor shortages in certain occupations. This is of course, a broad social, economic and educational issue. Many U.S. companies have been very concerned about the quality as well as the availability of suitable employees and have funded and participated in various programs to improve the overall situation, through scholarships, donations of equipment to schools, sponsorship of science talent searches, grants to colleges and universities, matching gifts, and so on.

U.S. companies look primarily to the U.S. workforce to fill these positions, but as we all know, there is a critical shortage of science and engineering graduates, especially with advanced degrees. There continues to be an increasing number of foreign student graduates, many of whom would like to remain in the U.S., but current U.S. immigration laws make it extremely difficult to employ them on a permanent basis.

Australia and Canada, who allow about two-thirds of the world's total legal immigration, are far more successful at attracting talented immigrants than we are. This is primarily due to the fact that our legal immigration system favors family unification. 75% of the legal immigrants in 1987 were granted entry because they

were related to a U.S. citizen or a resident, while only 4% were admitted for employment. It is obvious that our current immigration laws do not promote the immigration of highly skilled people, despite the shortages in certain occupations. We are not asking to take away from any other group; we merely want to keep our competitive edge in the world market.

In the present global business environment, the ready exchange of key personnel is essential to the efficient operation and continuous profitability of multinational corporations. To compete effectively in this market place, U.S. companies need immigration laws that provide predictability in the planning of international movement of key personnel. They also need expeditious procedures that assure that personnel decisions can be implemented within reasonable time frames. Mobility of key personnel is essential for proper corporate functioning in the international economy. Current immigration laws do not provide the needed flexibility and efficiency required when businesses make the difficult decision, with its attendant relocation costs, to bring a key foreign employee to the U.S. It should be pointed out that we are not talking about large numbers of people. Companies do not transfer and rotate employees without considerable thought, analysis and consideration. These relocations are expensive, they disrupt family living patterns and are not readily acceptable to working spouses.

In many important science and engineering fields, foreign employees have done some of the most innovative research, which U.S. companies must have access to and take advantage of in order to continue to be competitive in an ever increasingly competitive world market. Foreign managers and marketing specialists can bring to U.S. firms their unique knowledge of local marketing conditions and consumer preferences that can make the difference between success and failure in penetrating foreign markets. Rotational and cross-training of managers, specialists and technicians is needed for companies to develop an international cadre of executives who can compete with those of our foreign counterparts. A recent study by Korn/Ferry International and Columbia University stated and I quote: "In the 21st century, successful firms will be those that have adopted their corporate cultures to

the reality of international economic integration. This means that managers and their bosses must not only be attuned to the global marketplace, they must be a part of it. Corporations must hire increasing numbers of foreign nationals and fully assimilate them into the structure of the parent company. If you can imagine a foreigner sitting at the CEO's desk in the year 2000, then your corporation has made the quantum leap to the next century."

Yet with this in mind, our present legal immigration laws and policies are rooted in legislation enacted in 1952 and have failed to keep up with these evolving needs. As a result, U.S. companies that need the skills of international personnel, confront a variety of disconcerting obstacles in a process characterized by inflexibility, delay, and an absence of predictability. The ability to have the right person with the best technical or managerial skills in place at the best possible moment can make the difference between a successful project undertaken ahead of the foreign competitors, and an also-ran position that might effectively close the U.S. company out of the market altogether. For example, a third preference visa petition filed in February of 1989 is only now, over 18 months later, being processed and the wait for the sixth preference is backlogged well over three years. This is obviously not acceptable and solutions are urgently needed now.

The shortage of scientific talent in the U.S. is of great concern to our member companies. One company said: "We spent over \$1.4 billion on R&D in 1989 and we employ over 3,000 Ph.D.'s in the U.S. alone. The backbone of our company is R&D which we need to maintain our competitive edge. If we are unable to staff these positions with U.S. citizens or foreign nationals, this would have a major detrimental impact on our global competitive position." Another member company says: "We have a very difficult time finding scientific talent in the U.S. We have been able to hire some foreign talent in the past for positions in the U.S. However, we are now competing with European and Asian companies for these individuals. The competition for scientific talent is heating up and we sincerely hope that any changes to immigration laws will make it easier to hire foreign scientists and engineers."

You asked us to address several specific problems dealing with employing foreign nationals in the U.S.

Business Immigration In General

1. Do immigration laws prevent U.S. companies from using qualified immigrants for jobs in the U.S.?

The answer is yes. And the reason is simply that there are not enough employment related visas available under our current system. The long delays I referred to earlier, are a direct result of the shortage of visas in the 3rd and 6th preferences. Companies cannot operate effectively with such long delays, when they need to transfer an individual who is essential for the success of a particular business, product or new technology. Furthermore, it must be understood that the present system charges visas to spouses and children against already low quotas. We suggest an increase in the number of employer sponsored visas from the current level of 54,000 to 150,000, with an allocation of 90,000 to professionals, managers and executives and 60,000 to the current 6th preference. This could be expected to meet current needs and contribute to the substantial reduction of the current backlog in the employer sponsored categories.

Non-immigrant Employment

2. Do U.S. companies have difficulty bringing foreign scientists and engineers to the U.S. on a temporary basis?

There are many problems. Although the new H visa regulations issued by the INS in February have helped somewhat, they have substantially increased the documentation requirements, and we still have the problem of working spouses of H employees, who are not permitted to work in the U.S. with the derivative status they are given. As stated earlier, many companies use the H category to staff research activities in the U.S., and have difficulty doing so, but the present House immigration bill would place an annual cap on the number of H admissions and would subject these jobs to a labor certification approval. Needless to say, our members are very opposed to a cap which would cause delays of several months, at a time when the

ability to move quickly to respond to current competitive issues is paramount.

We have major problems with the L-1 intracompany transferee category. Over the last ten years, the INS has drifted away from the original congressional intention of transferring key company personnel to the U.S., and have issued regulations that include very narrow and restrictive definitions of managers, executives and specialized knowledge employees. Managers are required to spend the majority of their time on personnel-type duties and must supervise "professionals". In today's world, companies have individuals who are in critical positions, that do not have any staff reporting to them and subsequently do not fit the INS managerial definition. These definitions need to be updated to reflect current business realities. Many foreign scientists and engineers use the L-1 specialized knowledge category which has been given different and sometimes unworkable interpretations by the INS. Proper, realistic, definitions, that coincide with the original congressional intent when the L-1 category was enacted, need to be included in any new immigration legislation.

Labor Certification

3. Does the labor certification process hinder our efforts to develop a qualified workforce in the U.S.

The permanent labor certification process needs to be streamlined and made more efficient. Almost 90% of all applications filed are eventually approved, but this is accomplished only after a significant expenditure of time, up to a year in some regions, and at significant expense to both private companies and the taxpayers. U.S. companies and the Department of Labor would both benefit by the expansion of the occupations and positions listed in Schedule A, after it has been demonstrated that a particular occupation is in short supply. This can be done on a regional basis within the current system. A provision that would require an occupation to be scheduled for say two years, once ten certifications in that occupation are issued within a region, would both shorten and reduce the expense involved.

The business community believes that the labor attestation process contained in the current House bill, will in practice be worse than the current labor certification process and recommend that it be removed from the bill.

Job Sourcing

4. Does U.S. immigration law in any way affect what jobs companies place in the U.S. and what work they do overseas?

Although this has not happened much in the past, we are beginning to hear about problems in the research area. Highly skilled researchers are in short supply in the U.S., and companies are having difficulty dealing with the 18 months it now takes to get permanent employment authorization. The H visa could be a temporary solution, but again, the working spouse issue is a problem. A few companies are now considering moving their research facilities abroad in order to adequately staff their research projects. At least three member companies have already transferred their R&D activities to France, Germany and the U.K. to maintain their competitive edge. There is also the danger that companies will scale down their R&D spending or delay R&D projects. One company said: "The shortage of scientific Ph.D.'s is slowing down crucial R&D projects. Our company is definitely falling behind our foreign competitors."

You can appreciate the ramifications if this trend continues, and it underscores the need for more employment visas.

Point System

5. Would a point system, as proposed in S.358, enable more scientists and engineers to receive visas?

As it currently exists, S. 358's point system would provide some minor benefits but it would not meet the specific job requirement needs of a company. An engineer might qualify, but he or she might not have the specific product or market experience that is needed. We feel that employer sponsored immigration, by a specific qualified immigrant for a specific job, after labor certification, is the best way to determine and fill actual shortages in the U.S. work force. We do support experimentation with "new seed" immigrants, but suggest that more emphasis be placed on education, training, experience and job skills.

Foreign Students

6. One-half of the graduate students in many scientific and technological disciplines are foreign students. We are spending valuable resources to train them. To what extent do immigration laws impact on their remaining in the U.S. after graduation?

With the current 3rd preference backlog, it is virtually impossible to employ a graduating foreign student on a permanent basis in the U.S. The only avenue is to employ the graduate on a temporary basis with an H visa, but this is only a temporary solution, if the company wants the individual to remain in the U.S. for their entire career. In addition, many positions require government security clearances and can only be filled by U.S. citizens. The time spent in the U.S. on an H visa can not be applied to the total time required to become a naturalized U.S. citizen. An increase in employment related visas would help to improve the return on our investment.

Conclusion

In conclusion, the interest of U.S. companies, and the U.S. as a whole, will best be served by legal immigration reform that provides adequate attention and resources to employer-sponsored immigration. Reform must include increased allocation of permanent visas to employer-sponsored immigrants, with immigrant and non-immigrant revisions that better reflect business needs and priorities, a streamlined labor certification process with expansion of the schedule of precertified occupations in known job shortage fields, and a system that provides clear predictability and expeditious processing. Only if the U.S. moves forcefully to keep its competitive edge in the international market place will the economic well-being and long-term employment prospects of U.S. citizens be assured.

Thank you again for the opportunity to present the views of the National Foreign Trade Council on behalf of its members.

Mr. BROWN. Thank you very much, Mr. Tekely.
Doctor Cotter, please proceed.

**STATEMENT OF DR. MARTHA A. COTTER, EXECUTIVE OFFICER
FOR GRADUATE PROGRAMS IN CHEMISTRY, RUTGERS UNIVER-
SITY, NEW BRUNSWICK, NEW JERSEY**

Dr. COTTER. Mr. Chairman and distinguished members of the subcommittee. I am Martha Cotter, a professor of chemistry at Rutgers, the State University of New Jersey, and a researcher in the field of physical chemistry. I am also the executive officer or vice chair of the chemistry department with responsibility for our graduate programs.

I appear at your invitation to testify on the interrelationship between current efforts to increase scientific manpower and to approve new immigration legislation. My testimony reflects the views of my colleagues and I at Rutgers and those of the American Association of University Professors. I appreciate your invitation, and I am delighted to have the opportunity to testify on this important issue.

I would like to make some rather general remarks at the outset and then discuss the impact of current immigration law on science and engineering departments. Finally, I would like to express some concerns about the immigration bill, H.R. 4300, now being considered in the House of Representatives.

My major concern with respect to any proposed changes in current immigration law is that such changes should not make it more difficult for universities and research laboratories to hire the best and the brightest young scientists available in the world. In my opinion, American science and technology can remain competitive only by hiring the best talent available, regardless of the country of origin.

I wish that the best and the brightest young scientists were in large part American, but increasingly this is not the case. Both the number and the quality of Americans seeking advanced degrees in science and engineering have decreased markedly over the last decade. During this same period, many American universities have been inundated with large numbers of foreign, particularly Asian, science and engineering students of outstanding ability and promise. As a result, the pool of outstanding young scientists and engineers is becoming increasingly non-American. Let me use my own department as an example. The Graduate Faculty in Chemistry at Rutgers University, New Brunswick, has 48 members, of which only 5 are foreign born; moreover, 3 of these 5 are assistant professors. On the other hand, our graduate student body, which was 25 percent foreign in 1982, is now nearly 60 percent foreign.

The decline in interest in science and engineering among American students is a serious problem with a variety of causes. For the long-term health of the American economy, it is clear that we must reverse this decline and increase the supply of excellent young American scientists and engineers. In the short term, however, I believe that we have little choice but to recruit increasing numbers of professors and researchers from among non-immigrant aliens,

particularly foreign doctoral graduates of American universities, many of whom are eager to remain in the United States.

In discussing the impact of immigration law on American universities, one must keep in mind that major research universities both train future scientists and do research. Thus, immigration regulations affect science and engineering departments not only in the hiring of faculty members, but also in hiring other researchers such as postdoctoral fellows and research associates, and in the recruiting of graduate students. Moreover, graduate students and postdoctoral researchers are extremely important to the success of academic research.

The impact of current immigration regulations on the functioning of science and engineering departments at Rutgers University can be summarized by stating that current immigration procedures are complex, time consuming, and annoying in several respects, but they have not, in our experience, constituted insurmountable barriers to hiring foreign faculty members and postdoctoral researchers or to recruiting high quality graduate students. I do not believe, however, that this will continue to be the case if the number of alien researchers offered positions in American universities and research laboratories increases rapidly, as I think it must over the next several years. I do not think that the immigration system can successfully handle greatly increased numbers of scientists and engineers seeking permanent residence unless a priority higher than 3rd preference is given to professors and researchers. Furthermore, given the skewed distribution of nationalities in the current pool of outstanding graduate students and postdoctoral fellows, it may also be necessary to relax the per-country limit of 20,000 immigrants per year, at least with respect to a few countries.

Finally, I would like to comment very briefly on the proposed legislation, H.R. 4300. As you know, this legislation would establish a new category of priority workers called "outstanding professors and researchers." While my colleagues and I applaud this proposed special recognition of professors and researchers, we have several specific concerns with respect to H.R. 4300.

First, we are concerned that inclusion in the category of outstanding professors and researchers might be restricted to established academic or research "stars" from abroad. We will not solve our scientific manpower problems by luring a few big name foreign scientists and engineers to the United States. Rather, a more practical source of highly qualified professors and researchers to fill our short-term needs is the pool of recent foreign Ph.D. graduates of American universities. The best of these young scientists and engineers should be included in the category of outstanding professors and researchers; otherwise, the establishment of this new category would be of very limited help to most scientific and engineering departments.

Secondly, we would not want the establishment of this new category to preclude alien professors and researchers from obtaining immigrant status via the labor certification route.

Third, we are concerned about professors competing for immigrant visas with industrial and Government researchers, as well as aliens of extraordinary ability in the arts, education, business, etc. Since the supply of and demand for other types of researchers are

much larger than the supply and demand for professors, we are concerned that the number of alien researchers will overwhelm the number of alien professors in the queue for permanent residence. Furthermore, we argue that professors merit special consideration since they both do research and train the next generation of researchers. We believe, therefore, that the legislation should provide for an equal division between professors and other researchers of immigrant visas granted to outstanding professors and researchers.

Fourth, we are concerned that the proposed revision of the labor certification process would make it still more difficult for universities to hire professors and other researchers via this route.

And finally, we are concerned that the bill might require a university to go through the labor certification process for every postdoctoral researcher it wishes to hire on an H-1 visa. If so, this would consume enormous amounts of time and effort, and the resulting delays in getting postdoctoral researchers into the laboratory would wreak havoc on the research programs of many faculty members.

In conclusion, I thank you again for this opportunity to testify before this distinguished committee. I would like to submit my complete statement for the record and I welcome the opportunity to respond to your questions.

[The prepared statement of Dr. Cotter follows:]

Statement of Dr. Martha A. Cotter
Executive Officer for Graduate Programs in Chemistry
Rutgers, The State University of New Jersey
before a hearing of the
House Committee on Science, Space and Technology
Subcommittee on Science, Research and Technology
July 31, 1990

Mr. Chairman and distinguished members of the Subcommittee.

I am Martha Cotter, a faculty member and researcher, a professor of chemistry at Rutgers, The State University of New Jersey, and a physical chemist. I am also the executive officer or vice chair of the chemistry department of Rutgers University, New Brunswick, with responsibility for our graduate program. I have been a member of the chemistry faculty at Rutgers University since 1972.

I appear, at your invitation, to testify on the interrelationship between current efforts to increase the number of scientific and engineering personnel and to approve new immigration legislation. My testimony reflects the views of my colleagues and myself and those of the American Association of University Professors. I appreciate your invitation, and I am delighted to have the opportunity to testify on this important issue.

I would like to make some rather general remarks at the outset and then discuss the impact of current immigration law on science and engineering departments. Finally, I wish to express some concerns about the immigration bill, H.R. 4300, now being considered in the House of Representatives.

My major concern with respect to any proposed changes in current immigration law is that such changes should not make it more difficult for universities and research laboratories to hire the best and the brightest young scientists available in the world. In my opinion, American science and technology can remain competitive in the Twenty-first Century only by hiring the best talent available, regardless of the country of origin.

I wish that the best and the brightest young scientists were in large part American, but increasingly this is not the case. Both the number and quality of Americans seeking advanced degrees in science and engineering have decreased markedly over the last decade. During this same period, American universities have been inundated with large numbers of foreign, particularly Asian, science and engineering students of outstanding ability and promise. As a result, the pool of outstanding young scientists and engineers is becoming increasingly non-American. Let me use my own department as an example. The Graduate Faculty in Chemistry at Rutgers University, New Brunswick, has 48 members, of which five are foreign-born; moreover, three of these five are assistant professors. On the other hand, our graduate student body, which was 25% foreign in 1982, is now nearly 60% foreign.

The decline in interest in science and engineering among American students is a serious problem with a variety of causes, ranging from poor preparation in math and science in our elementary and secondary schools to the 1980's ethos that held that only professions with a very large and rapid financial payoff were worthy of pursuit. For the long-term health of the American economy, it is clear that we must reverse this decline and increase the supply of excellent young American scientists and engineers. In the short term, however, I believe that we have little choice but to recruit increasing numbers of professors and researchers from among non-immigrant aliens, particularly foreign doctoral graduates of American universities, many of whom are eager to remain in the United States. The need to recruit non-immigrant professors is particularly acute since the number of Americans preparing for academic careers in science and engineering is not sufficient to meet

projected national needs. Foreign professors will not take jobs away, therefore, from qualified Americans.

I have seen some recent data provided by Professor Michael A. Olivas of the University of Houston Law Center which demonstrates the relatively few non-immigrant aliens who have received H-1 visas under the category of postsecondary teachers. For 1986 the number was 1,133 out of a total of 54,426 non-immigrants provided H-1 visas. In the same year the status of 340 non-immigrant aliens listed as postsecondary teachers with H-1 visas was adjusted to permanent status. I have attached a table provided by Professor Olivas to my testimony.

Historically, of course, the United States has been the fortunate beneficiary of an open immigration policy for scientists and engineers. The United States, primarily through its universities, gave refuge to scientists and engineers in the 1930's and other periods of world turmoil, and these researchers made major contributions to the development of American science and technology. We are again in the position to benefit from current upheavals in various parts of the world. I think it would be very foolish not to take advantage of this opportunity.

In discussing the impact of immigration law on American universities, one must keep in mind that major research universities both train future scientists and do research. Thus, immigration regulations affect science and engineering departments not only in the hiring of faculty members but also in hiring of other researchers such as postdoctoral fellows and research associates, and in the recruiting of graduate students. Moreover, graduate students and postdoctoral researchers are extremely important to the success of academic research. They are the footsoldiers of the academic research enterprise as well as

the world's future scientists and engineers. The quality of research produced by an academic department is closely related to the quality of its graduate students and postdoctoral fellows. As the pool of highly qualified students and postdoctoral fellows has become increasingly foreign, the immigration regulations relating to non-immigrant students and postdoctoral researchers have become of increasing importance to all of us in academic research.

With this background, let me discuss the impact of immigration regulations on the functioning of science and engineering departments at Rutgers University. In particular, I shall discuss impediments the current immigration system poses with respect to hiring faculty members, hiring postdoctoral researchers, and recruiting graduate students.

To the best of my knowledge, immigration regulations have not prevented any department at Rutgers University from hiring any non-immigrant alien who accepted an offer of a tenure-track or tenured faculty position. However, I have heard informally that the inability of the university to guarantee an eminent European academic that he would receive a green card within some specified period of time was a major contributing factor in the decision by that eminent academic not to accept our offer of a senior faculty position. Moreover, obtaining permanent resident status is a slow, cumbersome process that is expensive in terms of required paperwork and can be quite nerve-wracking for the foreign professor in question. In our geographic area, labor certification now takes anywhere from five to eighteen months, and it takes another several months ~~and it takes another several months~~ ~~on one's nationality~~ to obtain permanent residence.

I also do not know anyone at Rutgers University who has been

prevented from hiring a postdoctoral fellow because of immigration regulations. On the other hand, the inefficiency of the Immigration and Naturalization Service (INS) can result in a significant delay in the appointment of a postdoctoral fellow and this, in turn, can cause financial hardship for the postdoctoral fellow as well as disrupt the research program of the faculty member wishing to hire him or her. For example, I know of several cases in my own department in which it took five or six months, rather than the customary one or two months, for a prospective postdoctoral fellow to obtain an H-1 visa because the INS lost or otherwise mishandled his or her visa application. As a result, the postdoctoral fellow spent several months unable to work in the laboratory and without any source of income.

The current immigration system can also cause problems in recruiting graduate students. Although the recruitment of very highly qualified graduate students is of great importance to science and engineering departments, the immigration system does not in any way consider the quality of the academic credentials of applicants for student (F-1) visas. Rather, the decision to grant or not grant a visa to a particular student is based solely on the judgment of a United States consular official as to whether the applicant is likely to return home upon completion of his or her graduate studies. Moreover, such judgments seem to be largely arbitrary and to show little consistency from country to country and from consulate to consulate. As a result of this system, we have been unable occasionally to recruit a very promising foreign student.

In summary, current immigration law and procedures are quite annoying in several respects, but they have not, in our experience, constituted insurmountable barriers to hiring foreign

faculty members and postdoctoral researchers or to recruiting high quality graduate students. I do not believe, however, that this will continue to be the case if the number of alien researchers offered positions in American universities and research laboratories increase rapidly as I think they must over the next several years. I do not think that the immigration system can successfully handle greatly increased numbers of scientists and engineers seeking permanent residence unless a priority higher than third preference is given to professors and researchers. Furthermore, given the skewed distribution of nationalities in the current pool of outstanding graduate students and postdoctoral fellows, it may also be necessary to relax the per-country limit of 20,000 immigrants per year, at least with respect to a few countries.

Finally, I would like to comment briefly on the proposed legislation, H.R. 4300. This legislation would establish a new category of priority workers called "outstanding professors and researchers," which could be distinct from the category of aliens with extraordinary ability. While my colleagues and I applaud this proposed special recognition of professors and researchers, we have the following specific concerns with respect to H.R. 4300.

1. We are concerned that inclusion in the category of outstanding professors and researchers might be restricted to established academic or research "stars" from abroad. We will not solve our scientific manpower problems by luring a few big-name foreign scientists and engineers to the United States. Rather, a more practical source of highly qualified professors and researchers to fill our short-term needs is the pool of recent foreign Ph.D. graduates of American universities. The

best of these young scientists and engineers should be included in the category of outstanding professors and researchers; otherwise, the establishment of this new category would be of very limited help to most science and engineering departments. This would require consideration of academic promise as well as experience in deciding who is "outstanding" and counting doctoral and postdoctoral research toward the required years of experience.

2. While we applaud the proposed establishment of a priority category of professors and researchers who would be exempt from the labor certification process, we would not want the establishment of this category to preclude alien professors and researchers from obtaining immigrant status via the labor certification route. Nor should the establishment of this special category make it more difficult for scientists and engineers to obtain labor certification.

3. We are concerned about professors competing for immigrant visas with industrial and government researchers as well as aliens of extraordinary ability in the arts, education, business, or athletics and other specified categories. Since the supply of and demand for other types of researchers are much larger than the supply and demand for professors, we are concerned that the number of alien researchers will overwhelm the number of alien professors in the queue for permanent residence. Furthermore, we argue that professors merit special consideration since they both do research and train the next generation of researchers. We believe, therefore, that the legislation should provide for an equal division between professors and other researchers of immigrant visas granted to outstanding professors and researchers.

4. We are concerned that the proposed revision of the labor certification process would make it more difficult for universities to hire professors and other researchers via this route. The labor certification process is currently slow and expensive in terms of administrative time and effort. The proposed creation of a complex mechanism to deal with challenges to attestations concerning recruitment efforts, wages, and working conditions would probably make the process still more time-consuming and expensive for universities.

5. We are concerned that the bill might require a university to go through the labor certification process for every postdoctoral researcher it wishes to hire on an H-1 visa. If so, this would consume enormous amounts of time and effort, since obtaining an H-1 visa, unlike labor certification, takes only a month or two and requires relatively little paperwork. Many large research universities, moreover, process hundreds of applications for H-1 visas every year. The resulting delays in getting postdoctoral researchers into the laboratory would wreak havoc on the research programs of many faculty members. During the past 12 months my campus, separate from the medical and law schools, processed approximately 100 applications.

In conclusion, my purpose today is to relate the urgent need for scientific and engineering personnel, specifically at research universities, to the proposed changes in the immigration law. I believe that this hearing will serve to provide documented evidence necessary for Congress to make a judgment about the proposed legislation. I commend the Subcommittee for the timeliness of this hearing because of the inquiries American faculty and universities and the American Association of University Professors are receiving from faculty members and new

administrators in Eastern European institutions about policies, practices, and standards of American universities. Many have expressed their desire to emulate our universities.

I welcome the opportunity to respond to your questions.

H-1's
Awarded
in 1986

1,133
54,426

postsecondary teachers
total H-1

Non-Immigrants adjusted to Permanent Resident, 1986

(from H-1) 340, including 34 exempt (5487 total)

*(from J-1), 221, including 44 exempt (1279 total)

(from L-1), 6, including 2 exempt (2433 total)

* includes J-1's meeting 2 year return requirement and waivers

Totals

cumulative	(H-1) <u>1377</u>	(H-2) <u>32</u>	(H-3) <u>2</u>	(J-1) <u>7081</u>	(L-1) <u>86</u>
to 1986	total 53,987	26,252	2,870	117,136	40,885

Sources: Unpublished data by Statistical Branch, INS; Statistical Yearbook, INS; telephone communication, Houston District INS, July 1990. Michael A. Olivas, Foreign Policy: Immigration "Reform" and U.S. Higher Education, forthcoming. Research support provided by the Spencer Foundation; no findings should be construed as being those of the Spencer Foundation.

CURRICULUM VITAE

Martha A. Cotter

Born: March 18, 1943 in Granite City, Illinois

Present address: 63 Leigh Avenue, Princeton, New Jersey 08542

Marital status: married with no children

I. EDUCATION

B.A. in Chemistry (with High Honors), Southern Illinois University, Edwardsville, June 1964

Ph.D. in Physical Chemistry (with Distinction), Georgetown University, May, 1969

Thesis Advisor: Daniel E. Martire

Dissertation Title: "Statistical Mechanics of Rodlike Particles. Application to the Nematic $\rightarrow$ Isotropic Transition in Liquid Crystals"

II. PROFESSIONAL EXPERIENCE

1. Postdoctoral Associate (with Daniel E. Martire)
Chemistry Department, Georgetown University
June - September 1969
2. Postdoctoral Associate (with Benjamin Widom)
Department of Chemistry, Cornell University
September 1969 - September 1970
3. Postdoctoral Associate (with Frank H. Stillinger)
Bell Laboratories, Murray Hill, New Jersey
September 1970 - September 1972
4. Assistant Professor of Chemistry
Rutgers, The State University of New Jersey
September 1972 - June 1978
5. Associate Professor of Chemistry
Rutgers, The State University of New Jersey
July 1978 - the present
6. Executive Officer (Vice-Chair) for the Graduate Program
Department of Chemistry
Rutgers, The State University of New Jersey
July 1984 - the present

III. AWARDS, FELLOWSHIPS, AND HONORS

1. Alfred P. Sloan Foundation Research Fellowship, 1974-78
2. Rutgers Research Council Summer Fellowship, 1974
3. Rutgers University Nominee for a Dreyfus Teacher-Scholar Award, 1975

IV. RESEARCH INTERESTS

Statistical mechanical investigations of liquid crystalline/micellar states of matter, with particular emphasis on the relationship between molecular structure and interactions and the stability and properties of various mesophases; molecular theories of liquids and liquid mixtures

V. PROFESSIONAL ACTIVITIES

Invited Lectures at International Conferences

1. "Hard Particle Theories of Nematics" and "The van der Waals Approach to Nematic Liquids", NATO ADVANCED STUDIES INSTITUTE on The Molecular Physics of Liquid Crystals, Corpus Christi College, Cambridge University, August 21 - September 3, 1977
2. "Statistical Mechanical Studies of Intermolecular Interactions in Mesogenic Solutions", V INTERNATIONAL SYMPOSIUM ON SOLUTE-SOLUTE-SOLVENT INTERACTIONS, Florence, Italy, June 2-6, 1980
3. "The van der Waals Theory of Nematic Liquid Crystals", ROYAL SOCIETY DISCUSSION MEETING on The Physics, Chemistry, and Applications of Thermotropic Liquid Crystals, The Royal Society, London, October 27-28, 1982
4. "Molecular Theories of Nematic Liquid Crystals", IX INTERNATIONAL LIQUID CRYSTAL CONFERENCE, Bangalore, India, December 6-10, 1982

Professional Service

1. Regular referee for *The Physical Review A* and *Physical Review Letters*, *Molecular Crystals and Liquid Crystals*, and *Journal de Physique*.
2. Review occasional manuscripts for *Liquid Crystals*, *Molecular Physics*, the *Journal of Chemical Physics*, and *Macromolecules*.
3. Review occasional grant proposals for the National Science Foundation and the National Institutes of Health.
4. Discussion leader, Gordon Research Conference on Liquid Crystals, Santa Barbara, January 2-6, 1978
5. Session chair, IXth International Liquid Crystal Conference, Bangalore, India, December 6-10, 1982

VI. PUBLICATIONS

1. "A Quasi-Chemical Lattice Treatment of Rod-Like Molecules. Application to the Nematic $\rightarrow$ Isotropic Transition in Liquid Crystals", M.A. Cotter and D.E. Martire, *Mol. Cryst. Liq. Cryst.* **7**, 295 (1969).
2. "Statistical Mechanics of Rodlike Particles. I. A Scaled Particle Treatment of a Fluid of Perfectly Aligned Rigid Cylinders", M.A. Cotter and D.E. Martire, *J. Chem. Phys.* **52**, 1902 (1970).
3. "Statistical Mechanics of Rodlike Particles. II. A Scaled Particle Investigation of the Aligned $\rightarrow$ Isotropic Transition in a Fluid of Rigid Spherocylinders", M.A. Cotter and D.E. Martire, *J. Chem. Phys.* **52**, 1909 (1970).
4. "Statistical Mechanics of Rodlike Particles. III. A Fluid of Rigid Spherocylinders with Restricted Orientational Freedom", M.A. Cotter and D.E. Martire, *J. Chem. Phys.* **53**, 4500 (1970).
5. "Free Energy in the Presence of Constraint Surfaces", F.H. Stillinger and M.A. Cotter, *J. Chem. Phys.* **55**, 3449 (1971).
6. "Comparisons of Two Simple Theories with Molecular Dynamics Results for Parallel Hard Squares", M.A. Cotter and H.L. Frisch, *J. Chem. Phys.* **57**, 1011 (1972).
7. "An Extension of Scaled Particle Theory for Rigid Disks", M.A. Cotter and F.H. Stillinger, *J. Chem. Phys.* **57**, 3356 (1972).
8. "Virial Expansions for a Binary Mixture Model and for a Related One-Component Model", J.P. Straley, M.A. Cotter, T.J. Lie, and B. Widom, *J. Chem. Phys.* **57**, 4484 (1972).
9. "Local Orientational Order in Ice", F.H. Stillinger and M.A. Cotter, *J. Chem. Phys.* **58**, 2532 (1973).
10. "The Hard Rod Fluid: Scaled Particle Theory Revisited", M.A. Cotter, *Phys. Rev. A* **10**, 625 (1974).
11. "Lattice Model for a Binary Mixture of Hard Rods of Different Lengths. Application to Solute Induced Nematic $\rightarrow$ Isotropic Transitions", H.T. Peterson, D.E. Martire, and M.A. Cotter, *J. Chem. Phys.* **61**, 3547 (1974).
12. "Lattice Models for Thermotropic Liquid Crystals", M.A. Cotter, *Mol. Cryst. Liq. Cryst.* **35**, 33 (1976).
13. "Hard Spherocylinders in an Anisotropic Mean Field: A Simple Model for a Nematic Liquid Crystal", M.A. Cotter, *J. Chem. Phys.* **66**, 1098 (1977).
14. "Consistency of Mean Field Theories of Nematic Liquid Crystals", M.A. Cotter, *Mol. Cryst. Liq. Cryst.* **39**, 173 (1977).
15. "Generalized van der Waals Theory of Nematic Liquid Crystals: An Alternative Formulation", M.A. Cotter, *J. Chem. Phys.* **66**, 4710 (1977).

16. "Generalized van der Waals Theory of Nematic Liquid Crystals: Requirements for Self-Consistency", M.A. Cotter, *J. Chem. Phys.* **67**, 4268 (1977).
17. "A van der Waals Theory of Nematogenic Solutions. I. Derivation of the General Equations", M.A. Cotter and D.C. Wacker, *Phys. Rev. A* **18**, 2669 (1978).
18. "A van der Waals Theory of Nematogenic Solutions. II. Applications to Binary Solutions with Spherical Solutes and Rodlike Solvents", M.A. Cotter and D.C. Wacker, *Phys. Rev. A* **18**, 2676 (1978).
19. "Hard Particle Theories of Nematic Liquids", M.A. Cotter, in *The Molecular Physics of Liquid Crystals*, G.R. Luckhurst and G.W. Gray, eds. (Academic Press, London, 1979), Chapter 7.
20. "The van der Waals Approach to Nematic Liquids", M.A. Cotter, in *The Molecular Physics of Liquid Crystals*, G.R. Luckhurst and G.W. Gray, eds. (Academic Press, London, 1979), Chapter 8.
21. "The van der Waals Theory of Nematic Liquids", M.A. Cotter, *Phil. Trans. Roy. Soc. (London)* **A302**, 127 (1983).
22. "Molecular Theories of Nematic Liquid Crystals", M.A. Cotter, *Mol. Cryst. Liq. Cryst.* **97**, 29 (1983).
23. "Lattice Model for Thermotropic Liquid Crystals. I. Derivation of the Partition Function", L. Petrone and M.A. Cotter, *Phys. Rev. A* **40**, 6021 (1989).
24. "Lattice Model for Thermotropic Liquid Crystals. II. Results and Conclusions", L. Petrone and M.A. Cotter, *Phys. Rev. A* **40**, 6045 (1989).
25. "Lattice Model for Thermotropic Liquid Crystals. III. Conformational Statistics of the Semiflexible Molecular Tails", L. Petrone and M.A. Cotter, *Phys. Rev. A* **41**, 3385 (1990).

Mr. BROWN. Thank you very much, Doctor Cotter. Your complete statement will be made part of the record.

Doctor Penner, please proceed.

STATEMENT OF DR. STANFORD S. PENNER, PROFESSOR OF ENGINEERING PHYSICS, UNIVERSITY OF CALIFORNIA, SAN DIEGO, SAN DIEGO, CALIFORNIA

Dr. PENNER. Mr. Chairman, distinguished members of the committee, I am very grateful for the opportunity to be here to testify on this important issue of increasing U.S. scientific and engineering manpower. I have prepared an extensive document in which I have attempted to summarize the study that was done by the National Academy of Engineering a few years ago that deals with the specific issue of U.S. trained and foreign engineers in the U.S. labor force. I have also prepared two appendices in which I have attempted to answer specific questions that were raised for this issue. With the Chairman's permission, I would like to confine my remarks to the specific questions that I have given in the appendix of my paper.

Mr. BROWN. Doctor Penner, the full text of your statement will appear in the record. You may proceed as you have indicated.

Dr. PENNER. Thank you very much.

Existing immigration laws impede and often prevent foreign scientists and engineers from receiving permanent visas for entry into the U.S. As the result, both U.S.-trained and foreign-trained graduates have encountered difficulties in finding permanent employment.

A point that should be noted is the introduction of de facto quotas for foreign-born graduate students at some public and private universities which has reduced the flow of highly skilled young scientists and engineers to the U.S. The number of qualified foreign-born students applying for graduate study is very much greater than the number that is actually being admitted.

Qualified U.S. citizens are not being displaced by foreign-born engineers who work for lower wages. In fact, our committee found that all engineers appear to be paid on the same scale and, generally speaking, both industrial and university employers favor qualified native-born over foreign-born engineers.

The statement that graduate training is subsidized in large part by U.S. taxpayers for foreign-born engineers who return to their countries of origin upon graduation is correct as stated. However, the inverse situation generally occurs for foreign-born engineers who come to the U.S. to study and who remain here after graduation. For this relatively much larger group, foreign citizens subsidize the pre-college and early college training of ultimately naturalized U.S. engineers at very considerable savings to U.S. taxpayers. More favorable immigration laws concerning highly trained scientists and engineers would increase the retention of these highly skilled people.

The returns of Asian-born American scientists and engineers represent both a loss and a gain to the U.S. While we are losing highly skilled people, at the same time we are gaining these same educated people abroad who are familiar with our ideals, teaching meth-

ods, and industrial activities. This familiarity should serve to facilitate long-term trade and exchange programs that are essential in view of the rapid globalization of science, engineering, and industry.

As chairman of the National Academy of Engineering Committee on the International Movement of Engineers, I have received quite a number of letters from university-based people in the U.S.S.R. These are people in their most productive years inquiring about faculty employment opportunities in the U.S. I am sad to say that thus far we have not been able to find suitable employment for these people. They are typically middle level people with the ranks of associate professors in their early 30s. It is much easier to place superstars whose best years may be past than relatively less well known but equally competent younger people.

With regard to the last question raised by the Chairman, I would like to note that I have had professional contacts with Ph.D. Russian scientists and engineers during most of my professional career. These people are generally very well trained, highly motivated, and excellent researchers with the same skills and training as our own good people. Their permanent entry into the U.S. would surely strengthen our R&D enterprise. To what extent they may also become successful entrepreneurs and industrial innovators is unknown.

I now come to some questions which were addressed to me in a personal letter from Chairman Valentine and I would like to comment on those, Mr. Chairman.

On the assumption that universities should hire the best qualified people as faculty members, the immediate exclusion of a very large percentage of Ph.D.s, about 60 percent in some important engineering disciplines, must necessarily prevent optimal selection in many instances.

Since current immigration laws interfere with the process of optimal selection of the best qualified young faculty member, the quality of the engineering education programs may also suffer.

It has been noted, and I would like to say again, that there has been a disproportionate growth of foreign-born engineers in the academic sector and I will not elaborate on these numbers. I would, however, like to say a few words about engineers in industry. The disproportionate growth of foreign-born students, postdoctoral researchers, and faculty members in the universities may be contrasted with slower corresponding growth of engineers in industry; from about 8.5 percent—3.5 percent non-citizens, 5 percent naturalized— in 1972, to 17.5 percent—3.5 percent non-citizens, 14 percent naturalized—by 1982.

In the absence of an adequate number of native-born engineers at all levels of education, potentially vacant positions have been filled by foreign-born engineers. Progressively larger substitutions have occurred at higher educational levels with disproportionately strong growth in the universities.

The last issue relates to this illusive question of competitiveness. We find that the research and development directors of 20 firms that account for a very large percentage of U.S. technological output have stated categorically that "industries are dependent on foreign talent and such dependency is growing."

The long-range solution to our problem must be clearly that of increasing the supply of engineers from native-born talent. This question has been addressed before at this meeting. I would like to add to the previous discussion one comment based on our committee deliberations. We find that about 95 percent of the baccalaureate degree recipients in engineering are U.S. born. Only a very small percentage of these go on to graduate school. There are, I believe, sound financial reasons for these decisions because the baccalaureates have unusual employment opportunities in industry almost immediately on graduation. In order to increase over the short-term the supply of U.S.-born Ph.D.s in engineering, we need a special fellowship program—and I would hope a very generous fellowship program—for native-born baccalaureates that will induce them to seek graduate training rather than immediate employment.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Penner follows:]

INCREASING U.S. SCIENTIFIC AND ENGINEERING MANPOWER

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Professor of Engineering Physics and
Director, Center for Energy and Combustion Research
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Testimony before the
House on Science, Space, and Technology
Subcommittee on Science, Research, and Technology
July 31, 1990

INCREASING U.S. SCIENTIFIC AND ENGINEERING MANPOWER*

by

S.S. Penner**

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I shall confine my remarks initially to pertinent information and conclusions derived from the National Academy of Engineering/National Research Council (NAE/NRC) study I chaired on "Foreign and Foreign-Born Engineers in the United States: Infusing Talent, Raising Issues", National Academy Press, Washington 1988.

1. U.S.-Born and Foreign-Born Engineers in Academia and Industry

In our pluralistic society, R&D, production and competitiveness goals will not be met for the foreseeable future without the participation of foreign-born engineers and scientists. While a potentially adequate pool of native-born talent could become available over the long term, recent data indicate that the total number of baccalaureate degrees granted per year in the U.S. is only about one million. Of these, about 20% or 200,000 per year will receive engineering or natural science baccalaureate degrees. At the same time, the number of PhDs granted per year to U.S. citizens is 8,800 per year in the natural sciences and engineering and this supply is augmented by about 5200 foreign-born PhDs, thus raising the total number of graduating PhDs in the U.S. in the natural sciences and engineering to about 14,000 per year. Of the total of 14,000 PhDs per year, women represent about 21% or 3000 per year while the numbers of hispanic and black PhDs are much smaller still. It is apparent that much larger numbers of native-born natural scientists and engineers would be graduated if it were possible to increase each of the following: the

*Testimony prepared for a "Hearing on Increasing U.S. Scientific Manpower," Tuesday, July 31, 1990, Rm. 2318, Rayburn House Office Building, U.S. House of Representatives, House Science, Space and Technology Committee, Subcommittees on Energy Research and Development and on Science, Research and Technology.

**The author is indebted to Dr. Alan Fechter, Director of the Office of Scientific and Engineering Personnel of NRC, for helpful discussions and a critical review of the numerical estimates given in this manuscript.

total number of college students and the fractions of male, female and minority students selecting natural science or engineering majors.¹

There has been a disproportionate growth of foreign-born engineers in the academic sector. Thus, the number of non-citizen assistant professors younger than 35 grew from about 10% in 1972 to about 55% by 1986, at which time nearly 5% of the assistant professors under 35 years of age were naturalized citizens. This preponderance of foreign-born assistant professors at about the 60% level will inevitably lead to a majority of foreign-born engineers at higher academic levels during the next two decades. In this connection, it should be noted that faculty hiring at major universities is a self-selective process determined by the incumbents. At present, foreign post-doctoral university researchers constitute about 70% of the total and this dominance may be expected to continue unless industrial employment opportunities for non-citizen PhD holders are greatly expanded. It should be noted that the ratios of qualified foreign-born to native-born PhD applicants generally exceed those observed in the graduate-student and faculty populations.

The disproportionate growth of foreign-born students, post-doctoral researchers and faculty members in the universities may be contrasted with the slower corresponding population growths of engineers in industry from 8.5% (3.5% non-citizens plus 5% naturalized citizens) in 1972 to 17.5% (3.5% non-citizens plus 14% naturalized citizens) by 1982. In industry, as well as in academia, relatively more rapid population growth has occurred for higher-degree holders, with the result that by 1982, about 15% of the baccalaureates, 22% of the holders of masters degrees, and 36% of the PhDs were foreign-born.

We may summarize the preceding observations by the statement that in the absence of an adequate number of native-born engineers at all levels of education, potentially vacant positions have been filled by foreign-born engineers. Progressively larger substitutions have occurred at higher educational levels with disproportionately strong growth in the universities.

2. Perceived Issues

Among the perceived issues associated with the influx of foreign-born engineers are the following:

(i) Qualified U.S. citizens are being displaced by foreign-born engineers who work for lower wages. In fact, all engineers appear to be paid on the same scale and, generally

¹ R.C. Atkinson, "Supply and Demand for Scientists and Engineers: A National Crisis in the Making," *Science*, Vol. 248, pp. 425-432 (1990).

speaking, both industrial and university employers favor qualified native-born over foreign-born engineers. Quota systems limiting the admissible fractions of foreign-born graduate students have been implemented at some major public and private universities.

(ii) The proficiency in English of foreign-born engineers may be inadequate and may represent a serious problem in the instructional programs at universities, where proficiency in English is often not an adequately enforced requirement for engineering teachers. There is some hear-say evidence to support this contention and other information that foreign-born and native university instructors are about equally effective in the classrooms.

(iii) Graduate training is subsidized by U.S. taxpayers for foreign-born engineers who return to their countries of origin upon graduation. While this last statement is correct as written, the inverse situation generally occurs for foreign-born engineers who come to the U.S. to study and remain here after graduation. For this relatively much larger group, foreign citizens subsidize the pre-college and early college training of ultimately naturalized U.S. engineers at very considerable savings to U.S. taxpayers.

(iv) Defense-related research is inhibited by (a) the relatively small pool of native-born higher-degree holders who are immediately eligible on graduation for classified work and (b) the predominance of foreign-born post-doctoral researchers on the campuses. Both of these statements appear to be valid but the impact on the U.S. industrial system may become less important as the cold war continues to wind down.

(v) The continued supply of foreign-born engineers may become problematical as our dependence on their skills grows and foreign countries restrict emigration in order to protect their own interests. This problem has not developed because increasing numbers of countries with growing numbers of potential students and professionals have become sources of foreign-born engineers for the U.S.

3. Augmenting the Numbers of U.S. Engineers at All Educational Levels

We have profited and continue to profit as the result of immigration of an unusually gifted group of individuals, who bring diversity and strength to the U.S. R&D enterprise at much lower expenditures than would be needed for the production of an equivalent number of U.S. engineers. Elimination of restrictions against permanent entry into the U.S. labor markets of U.S.-trained, foreign-born engineers is clearly in the best interests of the country. Selective admissions of foreign-trained and foreign-born engineers should be facilitated in growth areas where domestically-trained talent may be insufficient to meet the needs of either industry or academia. It may be desirable to assign the responsibility for selecting needed applicants to future employers, who should be encouraged to examine curriculum vitae provided by applicants, with the understanding that qualified immigrants

will be offered gainful employment by these employers who thus effectively become sponsors of foreign engineers with needed special skills.

4. Competitiveness in International Markets*

Preferential admission of immigrants with special skills should relate to augmenting U.S. competitiveness in international markets.

The needs for these skills reflect in large measure sociological and perhaps managerial deficiencies in our country, which have led to inadequate supplies of scientific and engineering talent. These structural deficiencies will require many years for correction and must begin with a thorough revision of our entire instructional programs from the lowest to the highest educational levels. It is doubtful that increased funding is the cure for these problems since we are already outspending our primary economic competitors on a per capita basis at all educational levels. Furthermore, the available evidence cannot make us comfortable with the thought that unequalled excellence of the research enterprise, as measured by publications, new discoveries and prestigious achievement awards, are sole determinants of this issue because we lost our competitive edge at a time when our research outputs and college instructional programs were supreme in the world, as defined by any objective measures. Long-term experience as an investor, board member and scientific advisor to a selection of new high-technology companies founded in the U.S. by highly-skilled professionals (often my former PhD students) has convinced me that there is no obvious relation between successful entrepreneurial activities and our educational programs. Success in high-technology innovation may elude the entrepreneur for any one of four crucial reasons: inadequate capital to meet the inevitable reversals that are met by new enterprises, difficulty in marketing even a superior product in competition with an established and often excessively-priced competitive product, inadequate quality control especially for competition in Japanese and other foreign markets, and balanced product improvement without bankrupting a struggling newcomer by excessive research and development expenditures. It is an interesting and as yet unanswered challenge to measure the potential entrepreneurial talents of highly skilled scientific and engineering personnel who may enter our country under favored arrangements in order to meet deficiencies in engineering and scientific manpower.

* The discussion in this section represents the author's personal opinions and was not considered in detail in the NAE/NRC deliberations.

5. Conclusions

Our industrial and educational activities will require augmentation of skilled engineering and scientific manpower from foreign lands for many years to come. This need may be reduced or eliminated over the long term by significant improvements of the U.S. educational system that lead to augmentation of engineering and scientific manpower as the result of greatly expanded participation in these rigorous disciplines by all segments of our society.

APPENDIX I:
COMMENTS ON THE ISSUES SPECIFIED FOR THE HEARING

(1) Existing immigration laws impede and often prevent foreign scientists and engineers from receiving permanent visas for entry into the U.S. As the result, both U.S.-trained and foreign-trained graduates have encountered difficulties in finding permanent employment, which has led to excessive numbers (about 70% of totals in engineering) of foreign-born post-doctoral researchers being employed on a temporary basis in U.S. universities.

The introduction of de facto quotas for foreign-born graduate students at some public and private universities has reduced the flow of highly skilled young scientists and engineers to the U.S.

Qualified U.S. citizens are not being displaced by foreign-born engineers who work for lower wages. In fact, all engineers appear to be paid on the same scale and, generally speaking, both industrial and university employers favor qualified native-born over foreign-born engineers.

Labor certification has impeded and occasionally blocked foreign engineers from receiving permanent entry visas.

(2) The statement that graduate training is subsidized in large part by U.S. taxpayers for foreign-born engineers who return to their countries of origin upon graduation is, of course, correct. However, the inverse situation generally occurs for foreign-born engineers who come to the U.S. to study and remain here after graduation. For this relatively much larger group, foreign citizens subsidize the pre-college and early college training of ultimately naturalized U.S. engineers at very considerable savings to U.S. taxpayers. More favorable immigration laws concerning highly trained scientists and engineers would increase the retention of these highly-skilled people.

(3) The return of Asian-born American scientists and engineers represent both a loss and a gain to the U.S. While we are losing highly-skilled people, we are gaining these same educated people abroad who are familiar with our ideals, teaching methods, and industrial activities. This familiarity should serve to facilitate long-term trade and exchange programs that are essential in view of the rapid globalization of science, engineering and industry. Given equal opportunities with native-born scientists and engineers, the retention rate for foreign-born engineers would be expected to increase.

(4) As Chairman of the NAE Committee on the International Movement of Engineers, I have received a number of letters from university-based people in the U.S.S.R. in their most productive years inquiring about faculty employment opportunities in the U.S. Thus far, we have not been able to find suitable employment for these people. It is much easier to place superstars whose best years may be past than relatively less well known but equally competent younger people.

I have had professional contacts with Russian scientists and engineers during most of my professional career. These people are generally very well trained, highly motivated, and excellent researchers with the same skills and training as our own good people. Their permanent entry into the U.S. would surely strengthen our R&D enterprise. To what extent they may also become successful entrepreneurs and industrial innovators is unknown.

APPENDIX II:

REPLIES TO THE WRITTEN QUESTIONS ASKED BY
THE HONORABLE TIM VALENTINE,
CHAIRMAN, SUBCOMMITTEE ON SCIENCE,
RESEARCH AND TECHNOLOGY, U.S.
HOUSE OF REPRESENTATIVES

(1) Current immigration laws impede the hiring of foreign engineers at universities and in industry. After graduation, PhD holders may remain in the U.S. for an automatic 12-month practical training period. Subsequently, the only immediately available openings become temporary post-doctoral research appointments in the universities. This feature of the immigration laws is directly responsible for the fact that these positions are now dominated to the extent of about 70% by foreign-born engineers. Many foreign-born PhD engineers are unable to obtain employment after graduation and will then return to their countries of origin, often with the hope of later return to the U.S. as immigrants. It is likely that upward of 70% of U.S.-trained PhDs ultimately become U.S. citizens.

(2) On the assumption that universities should hire the best qualified people as faculty members, the immediate exclusion of a very large percentage of PhDs (about 60% in some important engineering disciplines) must necessarily prevent optimal selection in many instances.

(3) Without immigration constraints, more than 70% of foreign-born PhDs would probably remain in the U.S. immediately after graduation.

(4) Since current immigration laws interfere with the process of optimal selection of the best-qualified young faculty members, the quality of the engineering education programs may also suffer. However, the actual impact on the quality of education is difficult to assess because so many of the best-qualified people do find employment as post-doctoral researchers in the universities.

(5) There has been a disproportionate growth of foreign-born engineers in the academic sector. Thus, the number of non-citizen assistant professors younger than 35 grew from about 10% in 1972 to about 55% by 1986, at which time nearly 5% of the assistant professors under 35 years of age were naturalized citizens. This preponderance of foreign-born assistant professors at about the 60% level will inevitably lead to a majority of

foreign-born engineers at higher academic levels during the next two decades. In this connection, it should be noted that faculty hiring at major universities is a self-selective process determined by the incumbents. At present, foreign post-doctoral university researchers constitute about 70% of the total and this dominance may be expected to continue unless industrial employment opportunities for non-citizen PhD holders are greatly expanded. It should be noted that the ratios of qualified foreign-born to native-born PhD applicants generally exceed those observed in the graduate-student and faculty populations. The disproportionate growth of foreign-born students, post-doctoral researchers and faculty members in the universities may be contrasted with the slower corresponding population growths of engineers in industry from 8.5% (3.5% non-citizens plus 5% naturalized citizens) in 1972 to 17.5% (3.5% non-citizens plus 14% naturalized citizens) by 1982. In industry, as well as in academia, relatively more rapid population growth has occurred for higher-degree holders, with the result that by 1982, about 15% of the baccalaureates, 22% of the holders of masters degrees, and 36% of the PhDs were foreign-born.

In summary, in the absence of an adequate number of native-born engineers at all levels of education, potentially vacant positions have been filled by foreign-born engineers. Progressively larger substitutions have occurred at higher educational levels with disproportionately strong growth in the universities.

(6) The R&D directors of 20 firms that account for a large percentage of U.S. technological output have stated that "industries are dependent on foreign talent and such dependency is growing".

The available evidence cannot make us comfortable with the thought that unequalled excellence of the research enterprise, as measured by publications, new discoveries and prestigious achievement awards, are sole determinants of this issue because we lost our competitive edge at a time when our research outputs and college instructional programs were supreme in the world, as defined by any objective measures. Long-term experience as an investor, board member and scientific advisor to a selection of new high-technology companies founded in the U.S. by highly-skilled professionals (often my former PhD students) has convinced me that there is no obvious relation between successful entrepreneurial activities and our educational programs. Success in high-technology innovation may elude the entrepreneur for any one of four crucial reasons: inadequate capital to meet the inevitable reversals that are met by new enterprises, difficulty in marketing even a superior product in competition with an established and often excessively-priced competitive product, inadequate quality control especially for

competition in Japanese and other foreign markets, and balanced product improvement without bankrupting a struggling newcomer by excessive research and development expenditures. It is an interesting and as yet unanswered challenge to measure the potential entrepreneurial talents of highly-skilled scientific and engineering personnel who may enter our country under favored arrangements in order to meet deficiencies in engineering and scientific manpower.

Mr. BROWN. Thank you very much, Doctor Penner.

Doctor Penner, that last remark you made is reflective of a problem that exists obviously in other areas than engineering. We commented earlier about the lack of funding for fellowships for scientists, not necessarily just graduates but postdoctoral, in the biological fields. Obviously, we would benefit from resources in all of the scientific fields to encourage graduates to proceed to graduate school and get their doctoral degrees. I suspect that the committee will recommend that we undertake some programs of that sort, but the problem continues to be lack of funding at the Federal level. Do you have any estimates as to what a robust program of the sort you suggest would cost?

Dr. PENNER. It will be expensive but I don't have any good estimates. I would like to make a remark though with regard to the other fields; it is a very parochial remark to be sure. The universities have already acknowledged that there is a crisis in getting engineering faculty members and they have admitted this by paying disproportionately large salaries to university professors; they are on a different scale in many institutions. We are saying that this same differential scale ought to be applied to the graduate students in engineering who are also in desperately short supply for native-born students.

Mr. BROWN. Are you saying, Doctor Penner, that there is a differential between engineering and other fields in university professorships?

Dr. PENNER. There is, yes, sir.

Mr. BROWN. You mean a professor of engineering gets more than a professor of english?

Dr. PENNER. Yes, sir. At the same rank—I don't know the exact numbers, they vary I am sure from school to school - - but in the University of California system, I believe it is something on the order of 20 percent differential pay.

Mr. BROWN. Is that justified on the basis of supply and demand primarily?

Dr. PENNER. Yes. It is justified on the basis that it is extraordinarily difficult to find engineering professors in critical disciplines, for example in robotics, or in other areas where the industrial opportunities are unlimited.

Mr. BROWN. Do you know if there has been any analysis of this made either by the Academy or other institutions?

Dr. PENNER. The differential costs that would be associated with this? I don't believe that there has been a careful study of the sort of numbers that we are talking about. Our committee felt quite strongly that this issue needed to be examined.

Mr. BROWN. There has always been a strong element in the university culture of recognizing equal rank with equal pay, and it is difficult for them to get away from it. The same thing, of course, is true of teaching at any level.

Dr. PENNER. We have no difficulty paying differential salaries to the people in the medical schools, for example. I believe it is something of the same idea that has been recognized for the engineers.

Mr. BROWN. You indicated, Doctor Penner, that engineers at the—I think you were talking about universities, but maybe industrial as well—that there is no distinction between foreign and U.S.-

born in terms of salaries; that they both tend to get the same salary.

Dr. PENNER. This was a specific issue that our committee was asked to address. To the best of our ability we were unable to find any distinction in the salaries paid to the engineers once they were hired.

Mr. BROWN. You are not the best person to ask this question of, but do you have any information bearing on whether that is true for other fields, such as the medical field?

Dr. PENNER. I'm sorry, I can't answer that question.

Mr. BROWN. It seems to be, just based on anecdotal information and observation, that there is a hierarchy of salaries for doctors in which the foreign-born seem to have the lower paid positions; but I don't know and if any of the rest of you know, I would like to hear whether there is any substantiation of that.

You made some additional remarks about the high quality of Soviet researchers, Doctor Penner, and that we don't seem to be getting fair access to those or that we are not making the opportunity for them to come in the way that we should. We will have a Soviet scientist testifying in the next panel. But do you have any information at all about whether or not most of these Soviet scientific and engineering immigrants may be going to Israel or to some other country?

Dr. PENNER. I have no information on that. The letters to which I referred were addressed to me because in the Soviet Union the Academy is essentially an executive agency. I believe that the people in the U.S.S.R. received copies of our report and they assumed that as chairman of this committee I might be in a position to help them and they therefore wrote to me and gave specific curriculum vitae. Typically, it was very interesting, it was one person writing on behalf of a whole group of people, three or four people, in what I would say were very important areas where they were trying to relocate as a group at a U.S. university. I have referred these letters to Doctor Fechter of the National Research Council, and he has been working trying to locate these people appropriately. But, as I said, we haven't been successful. He is here; I'm sure he would be happy to comment on that issue.

Mr. BROWN. It is interesting you should mention that because that was the pattern we followed after World War II in picking up German scientists and engineers in both countries; we picked them up in groups. We can trace the beginning of our Space Program to our picking up a very talented group of German scientists.

Dr. PENNER. I believe there are some real opportunities here. I am talking about strengthening the R&D enterprise. I don't want to make statements about what this implies for competitiveness or entrepreneurial activity because I don't know.

Mr. BROWN. Well, that's a rather large subject.

Mr. Tekely, you seem to be mounting a substantial program in connection with this immigration legislation and it has obvious benefits to you to get changes made in the law; likewise with the universities. Do you know whether there has been any effort to coordinate your approach to the Judiciary Committee, to the Congress in general, on this rather important subject?

Mr. TEKELY. Yes. Industry has got together and formed a coalition called the Business Immigration Coalition, where most major U.S. companies are represented and have presented their views and ideas to Mr. Morrison and his subcommittee throughout the whole process and continue to present their views and suggestions for improvement in business-related immigration.

Mr. BROWN. The question I was trying to get at was whether you have coordinated with other non-business groups, such as the university groups?

Mr. TEKELY. Oh, yes. We work very closely with some of the foundations and other institutions here in Washington through the Business Immigration Coalition.

Mr. BROWN. I am giving some thought as to how we can transmit the results of this hearing to Mr. Morrison and the Judiciary Committee because we want to indicate the importance which this committee attaches to the proper resolution of this problem. We hope to have some input in that connection.

A distinguished member, Mrs. Morella, from Maryland, has arrived. Do you have any questions?

Mrs. MORELLA. Thank you very much, Mr. Chairman. I appreciate that.

I have scanned your testimony and I am curious about a number of things that you can probably elucidate for me. Do you have any concept of the number of students who come here for science and engineering advanced degrees who are being paid by their home governments with the idea in mind that they will return to their countries and, therefore, serve there, having gained from our higher educational system? The reason I am asking that, of course, is whether that has some impact on our whole discussion today about whether or not our immigration laws should change so these students can stay here? Are you finding in your experience that a lot of them are paid for by their governments or by funds, foundations, that expect they will return?

Dr. PENNER. In my experience, the number of people who are being supported adequately from foreign sources for graduate study is very small. They may have a very small stipend and they usually, however, I believe, come without constraints initially. I think it would be a small number of people that we have seen who are required to go back because of support from abroad. I don't have accurate statistics.

Mrs. MORELLA. Would the rest of you tend to agree? Doctor Cotter?

Dr. COTTER. I have no statistics, but in my experience a relatively small number of students have some sort of support from their governments and an even smaller number of those students have what you would consider adequate support. At least at present, most of the foreign students that we see in chemistry are from various Asian countries or from South America, where their country is in many cases unable to really provide adequate levels of support. Even taking that into account, most students who come here, certainly in chemistry, come here supported by the institution they attend, either as teaching assistants or graduate fellows, something of that sort.

Mrs. MORELLA. I see. Mr. Tekely, you would tend to agree with that?

Mr. TEKELY. Yes. U.S. industry does at times help support individual foreign students through scholarship programs.

Mrs. MORELLA. It seems to be that the Foreign Affairs and Education and Labor Committees this year, more than ever, are approving various scholarships that are some exchanges, some are not, with people from not only Eastern and Central Europe but the African Continent. I just wondered if there seemed to be a great number of those and if that would alter things.

We have all heard the concept also that if you are going to open up your immigration for classifications for the experts in math and science, you are ultimately going to take jobs away from Americans. I am sure you have heard that and I just want to give you an opportunity to comment on whether there is some validity to that or whether it is poppycock.

Mr. TEKELY. There is a process in place that protects U.S. citizens, it is called the Labor Certification process, that every company must go through and get the approval from the Department of Labor before they can employ a foreign national to guarantee that there is not a qualified and willing U.S. citizen for that job. That process is in place and we would recommend that we keep that process.

Mrs. MORELLA. So there is no need to change that.

Mr. TEKELY. We need some improvement in the efficiency of the process; it now takes too long, it doesn't need to take that long. There are known shortages in certain occupations and we think we can within the current system make some changes that will shorten the whole process between the time that you identify a potential candidate and when you can bring them on board for employment.

Dr. COTTER. Let me respond. Certainly with respect to hiring non-immigrant aliens as university professors, it is clear that the number of Americans preparing for academic careers in science and engineering, as opposed to industrial careers, is—let me say the number of Americans preparing for academic careers in science and engineering is decreasing even more rapidly than the number of people preparing for careers in science and engineering in general. It is considerably below any sort of projected national need. So it is clear that at least in the next two decades, non-immigrant aliens are clearly not going to be taking jobs from qualified Americans.

Mrs. MORELLA. Do we also know that a number of these students do desire to get visas to stay permanently? Are we speculating that a certain percentage would want to, or do we know that they would want to by any measure? Doctor Penner?

Dr. PENNER. We do have some statistics for engineering Ph.D. graduates. The immediate retention rate is on the order of 50 percent, and I have seen estimates that ultimately the number coming back is as large as 70 percent of the U.S.-trained Ph.D.s. In a more personal sense, I have had a fair number of foreign-born Ph.D. students work with me, I believe about 15. Only one of these did not become a U.S. citizen.

Mrs. MORELLA. The final question, Mr. Chairman. This whole hearing, isn't it saying that there is something wrong with our educational system before you reach higher education?

Dr. PENNER. Definitely.

Mr. TEKELY. I think it even goes beyond that. There is just a basic problem with our culture, the way we view what is success, the way we define success.

Mr. BROWN. We are not here to undermine our culture.

Mrs. MORELLA. Never, never. But as we look to workforce 2000, picking up on this, where are going to be our women, our minorities entering the workforce. Everybody is mathematically, scientifically illiterate. I just think there should be more we're doing.

Dr. COTTER. I would just like to add that clearly there are a number of reasons for the declining interest in science and engineering among American students. One of them was addressed earlier in the hearing about the sort of sad state of science education and of scientists and engineers not getting out there and letting the world know that what we do is great and it is fun. There are also clearly many school systems in this country where the state of education in general is miserable and where there is no way that student is going to get the necessary background to go into any technical field, if, indeed, they are going to get the background to do anything beyond a very menial job. Also, I think in the 1980s, in particular, there was a particular problem with shall I say the ethos of the 1980s which led the best and brightest young American students to believe that any career which did not have a huge and immediate financial pay-off was not worthy of consideration. I have had very bright students who I was trying to convince to go on to graduate school in chemistry or physics ask me how much money I made per year. When I told them it was none of their business, they asked me whether it was less than some figure, and when I said yes, they essentially told me I was a chump. I think that perhaps that era is passing and maybe at least that component of the problem may improve somewhat. But it is a bad situation where you have much of the population who isn't prepared and the group that is prepared all want to be investment bankers. It is a problem.

Mrs. MORELLA. I want to thank the panel and I want to thank you, Mr. Chairman, for the opportunity to share some ideas.

Mr. BROWN. Thank you, Ms. Morella. I don't want to pursue the point that we are making here about changes in American culture, but I think it is quite obvious that it may be that cultural differences are at the root of the decline of the United States in its leading role in the world, not just in material or economic terms but in total terms, in our leadership in scientific, artistic, and other areas, because we have tended to put too much emphasis upon financial return on activities and that has lead to things like the savings and loan scandal and some of the rip-offs on Wall Street and so on. I truly hope that we are taking a different direction but I am not sure that we are at this point.

Now, I have no further questions. Let me express my appreciation to all of you for your very instructive testimony. We will excuse you at this point.

Mr. BROWN. We will call our last witness, Mr. Mark Handelman from the New York Association for New Americans, who will be accompanied by Doctor Rafail Kushak, a refugee scientist from the Soviet Union.

Unfortunately, we have a roll call vote on, so Mr. Handelman, you are going to get a coffee break right now because we are going to go vote and we will return just as quickly as we can.

[Recess.]

Mr. BROWN. We apologize to both of you for the interruption. I am sure you both are aware that we have a very heavy schedule on the Floor of the House and most of our members are over there participating in that action. If we fail to act today, the United States Government stops action because they can't borrow any more money.

Mr. HANDELMAN. We certainly understand.

Mr. BROWN. Mr. Handelman, you may proceed with your statement.

STATEMENT OF MARK HANDELMAN, EXECUTIVE VICE PRESIDENT, NEW YORK ASSOCIATION FOR NEW AMERICANS, NEW YORK, NEW YORK

Mr. HANDELMAN. Thank you Mr. Chairman and members of the Subcommittee on Science, Research, and Technology, my name is Mark Handelman, I am the Executive Vice President of NYANA, the New York Association for New Americans, which is the largest voluntary, non-profit refugee resettlement agency in the United States. Since 1949, NYANA has resettled over 300,000 refugees in the New York metropolitan area from 39 countries in about 16 waves of immigration. I also currently serve as Chairman of the Board of the National Immigration, Refugee, and Citizenship Forum, an organization that facilitates dialogue, information exchange, consensus and networking among agencies interested in refugee and immigration issues. I am pleased to come before you today to provide information about Soviet refugees arriving in the United States with training as engineers and scientists. There is the potential for this highly qualified and educated group of newcomers to serve as a valuable resource filling openings in the United States.

As a resettlement agency, NYANA provides a complete array of services such as short-term financial aid, English language instruction, and job skills training to individuals with backgrounds in a cross-section of occupations—from blue collar trades to Ph.Ds. Of special interest to this subcommittee, a significant and expanding proportion of our clients are engineers and scientists. There are engineers from more than 12 different specialties including civil, mechanical, environmental, metallurgical, chemical, marine, agricultural, and electrical engineering. In 1988, the year when large numbers of Soviet refugees began again to arrive into New York, 79 of our clients came as skilled engineers; in 1989, that number increased to 1,325. Thus far in 1990, we have assisted 826 engineers. By far, the largest numbers come with skills in mechanical engineering, electrical and electronics engineering, and civil or structural engineering. In 1989, the last year for which we have

complete data, 34 percent of arriving engineers were trained in mechanical engineering; 23 percent in the electrical and electronic disciplines; and 20 percent in civil or structural engineering.

During 1988, we assisted seven scientists. However, in 1989, that number jumped to 101 scientists who availed themselves of NYANA services. They primarily included chemists, physicists, mathematicians, and biologists. To date in 1990, about 100 scientists have been assisted by us. Beyond the more familiar scientific disciplines, there have been geologists, meteorologists, agronomists, and oceanographers; as well as highly specialized engineering talents, including those in printing technology and magnetic casting technology.

The question that certainly needs to be answered is: how successful are these emigre engineers and scientists in establishing themselves here in their professional areas of training and education? The barriers faced by these newly arrived refugees are daunting. Coming to the United States with advanced degrees, sophisticated training, and high hopes does not guarantee employment in one's occupational field. University-trained Ph.D.s must learn that there will be a need to start at an entry-level position. This requires will to work orientation and, further, an acknowledgement that an occupational status which was once highly respected among professional peers, does not carry the same weight or validity here. It has often been observed that engineers in the Soviet Union are afforded the status and respect Americans bestow upon physicians. That leaves Soviet-trained engineers with confusion regarding their place in an American occupational hierarchy. Many hours of counseling, vocational assessment, and job readiness training are needed to prime refugees for the job search experience.

The job search process is alien to Soviet refugees. In the Soviet Union, one gets a job upon completion of training or education and this is the job that is kept for life. Upward mobility or promotions are not concepts that are familiar to Soviet workers. Once again, reorientation for newly arrived refugees is vital. The process of searching for a job, including writing a resume and cover letter, scheduling interviews, preparing for interviews, and contemplating and accepting a job offer must be taught. For scientists and engineers interested in conducting research at a university, an orientation to collegiate conventions and practices are also important. They must learn what an academic calendar is so they can coordinate their job search efforts with a university's hiring schedule.

Perhaps the most striking and crucial barrier to employment is the lack of basic English language skills. Technical training is fundamental, but without the ability to communicate in English, employment is unattainable. Beyond that, NYANA has found that often times employers are not comfortable hiring someone who looks or sounds foreign. What is clear however, is without job-relevant English or, as well call it, vocational English as a second language training, none of NYANA's clients are able to secure employment.

For scientists and engineers in particular there is another obstacle to employment beyond the lack of English. The outcome of formal education received in the Soviet Union yields a degree that for all intents and purposes is the equivalent of a university-grant-

ed Bachelor degree in the United States. The practical, "hands-on" experience that many of NYANA's clients come with is usually based upon a technology that may be several years outdated. Computer programmers, for example, lack familiarity with American systems. Soviet training has provided them with an understanding of computer systems. However, they are unfamiliar with American software packages and sophisticated technology. Soviet engineers have little experience with designing computer-based models. Their experience has been with physical modelling. Consequently, these refugees are starting with disadvantages—they come from a world where their education and experience makes them well-respected; in the United States, their training does not give them the edge that they expected.

Finally, the state of the United States' economy serves as an obstacle to employment. Jobs for mathematicians, nuclear scientists, and rocketry engineers are scarce. Often, many of these jobs have citizenship requirements or security clearances associated with them that consequently eliminate refugees from consideration. Some jobs, such as geophysicists and geologists, while available in other parts of the country, are scarce or non-existent in the New York vicinity. The thought of relocating once again may be not appealing. Furthermore, when the economy is slow, buildings are not built, roads are not fixed, and universities do not hire that extra professor. Civil, mechanical, and electronic engineers will not find jobs. Research scientists will remain unemployed.

At NYANA we provide special services to overcome these obstacles. Firstly, we provide vocational training that goes beyond just skills or technical instruction: general English language, vocational English, and job search skills, all in addition to the technical training instruction. To meet the needs of our refugee engineers, NYANA has developed an Engineer Retraining Program to provide Soviet-trained engineers with knowledge of engineering occupational practices in the United States. We designed a demonstration program that offered short-term, intensive retraining in five engineering specialties. Funding was initially secured from foundations and other private sources. The program offers 72 hours of technical instruction which is conducted by bilingual instructors, Soviet engineers who have been in the United States for several years and who have been practicing and instructing in their specific engineering discipline. Courses are taught in English and the native language is used to clarify points and to explain difficult concepts. By using this instructional method, clients have the opportunity to learn the subject matter with its corresponding English vocabulary, as well as improve their general English language skills. Emphasis is placed on explaining the differences between American and Soviet engineering terminology and practices. Instruction, therefore, is given with the goal of contrasting the systems and teaching the American terminology.

Additionally, program participants receive 150 hours of vocational English and job skills instruction which includes an introduction to the capitalist economy, networking techniques, and preparing for an interview. The original program was funded to assist 96 engineers; we have now secured refugee social service funding from

New York State to enroll 120 in this retraining effort and foundation funds to help retrain another 58 engineers.

Generally, job placement figures from NYANA's vocational training programs range between 85 and 100 percent of those enrolled. Placement into highly skilled and higher paying professions typically runs at 70 percent. Of those that have already completed the Engineer Retraining Program, 45 percent were employed as engineers one month after program completion; an additional 27 percent have either found other employment or continued other education or training. NYANA's experience has indicated that it may take up to four months to place engineers in jobs upon training completion. Nonetheless, without training, it is improbable that many engineers could successfully gain employment in their chosen field.

Secondly, NYANA, in collaboration with the Committee of Concerned Scientists and the New York Academy of Sciences, has formed a Program for Refugee Scientists intended to help those who recently arrived to become integrated into the scientific life of the United States and to find employment in their chosen specialty. The program is supported by grants from foundations. Like the Engineer Retraining Program, it is limited in scope and size. Recently arrived refugee scientists apply to the Program for selection as participants. Participants are required to secure a commitment from a university which allows them to use their university as a site for scientific research for a year's duration. There is no cost to the university. During the year's assignment, the scientists are pursuing research and a job search. Foundation funding enabled 25 individuals to be placed at universities throughout the country; 16 have already secured permanent employment at universities for this fall.

Thirdly, to serve these professionals, NYANA has established an Emigre Advisory Committee, known as the EAC. Composed of former clients who have successfully attained jobs, as well as other professionals in the business world, the EAC provides liaison and networking connections for clients. Clients are referred to EAC members who hold jobs in the same field. They meet for informational interviews and EAC members advise clients as to how to secure positions in the field. Because former clients are serving on the committee, they can offer a dose of reality to current clients. Current clients hear details of pursuing a position from those who have proceeded them.

NYANA provides clients with many resources to facilitate their job search—access to typewriters and word processors so that resumes and cover letters may be prepared, access to telephones to arrange interviews, and a library of technical scientific documents in English and in Russian.

I would also like to tell you about a very innovative program that we are sponsoring in conjunction with the Federation Employment and Guidance Service in New York through the National Association of Jewish Vocational Services, and that is the development and support of a national computerized data bank listing vacancies in science and technical fields. Every JVS will be able to access data and enter data about job openings throughout the country, as well as enter client profiles of scientists and engineers seek-

ing such jobs. Software is currently being developed to make the match between cities that have jobs and cities that have clients looking for jobs.

Given NYANA's recent experience helping to place newly arrived Soviet scientists and engineers, I would like to offer the following recommendations to this subcommittee:

First, world of work orientation is fundamental. Foreign-born individuals must be appraised of basic economic and cultural differences between the United States and the Soviet Union. Once that is understood, English, vocational English, and job search skills must be made a part of all initial job readiness exercises. These services require special funding.

Second, expanded training opportunities for engineers and scientists should be made available. This requires rethinking of basic refugee resettlement strategies at the national level. Additional Federal funding of refugee-specific vocational training programs would serve to enhance the skills of those with professional and technical degrees who lack familiarity with American systems and the English language.

And last, on the employer side, potential employers must be made aware of the resource of the foreign-trained professional. Their technology may be slightly outdated and their English accented, but they are nonetheless a rich pool of workers available to fill vacancies in the science profession. It would be helpful if more media coverage could be obtained to emphasize to potential employers that such a valuable pool of employees is available.

I am gratified to be able to speak with you this morning and to discuss NYANA's experiences in preparing newly arrived engineers and scientists with critical information as they begin their new lives here in the United States.

Doctor Rafail Kushak, who is with me this morning, has a story that will perhaps be even more meaningful in terms of the subject we are discussing.

[The prepared statement of Mr. Handelman follows:]

Testimony by Mr. Mark Handelman
before the
House Committee on Science, Space and Technology
Subcommittee on Science, Technology and Research
July 31, 1990

Representative Valentine and members of the Subcommittee on Science, Research and Technology, my name is Mark Handelman. I am Executive Vice President of NYANA, the New York Association for New Americans, which is the largest voluntary, non-profit refugee resettlement agency in the United States. (Background information on NYANA, its mission and its service populations are provided in Appendix A at the end of this testimony.) I am also currently serving as Chairman of the Board of the National Immigration, Refugee and Citizenship Forum, an organization that facilitates dialogue, information exchange, consensus and networking among agencies interested in refugee and immigration issues. I am pleased to come before you today to provide information about Soviet refugees arriving in the United States with training as engineers and scientists. There is the potential for this highly qualified and educated group of newcomers to serve as a valuable resource filling openings in the United States.

As a resettlement agency, NYANA provides a complete array of services such as short-term financial aid, English language instruction and job skills training to individuals with backgrounds in a cross-section of occupations - from blue collar trades to Ph.D's. There are people from the arts: musicians, opera singers, performers, and painters. We see doctors, nurses, medical and

dental technicians. There are bookkeepers, taxi drivers, cooks, shoemakers and welders. And, of specific interest to this Subcommittee, a significant and expanding proportion of our clients are engineers and scientists. There are engineers from more than 12 different specialties including civil, mechanical, environmental, metallurgical, chemical, marine, agricultural, and electrical engineering. In 1988, the year when large numbers of Soviet refugees began to arrive, 79 of our clients came as skilled engineers; in 1989, that number increased to 1,325. Thus far in 1990, we have assisted 826 engineers. By far, the largest numbers come with skills in mechanical engineering, electrical and electronics engineering and civil or structural engineering. In 1989, the last year for which we have complete data, 34 percent of arriving engineers were trained in mechanical engineering; 23 percent in the electrical and electronic disciplines; and 20 percent in civil or structural engineering.

During 1988, we assisted seven scientists. However, in 1989, that number jumped to 101 scientists who availed themselves of NYANA's services. They primarily included chemists, physicists, mathematicians, and biologists. To date in 1990, about 100 scientists have been assisted by NYANA. Beyond the more familiar scientific disciplines, there have been geologists, meteorologists, agronomists and oceanographers; as well as highly specialized engineering talents, including printing technology and magnetic casting technology, to name a few.

The question that certainly needs to be answered is: how successful are these emigre engineers and scientists in establishing themselves here in their professional areas of training and education? The barriers faced by these newly arrived refugees are daunting. Coming to the

United States with advanced degrees, sophisticated training and high hopes does not guarantee employment in one's occupational field. University-trained Ph.D's must learn that there will be a need to start at an entry-level position. This requires orientation and, further, an acknowledgement that an occupational status which was once highly respected among professional peers, does not carry the same weight or validity here. It has often been observed that engineers in the Soviet Union are afforded the status and respect Americans bestow upon physicians. That leaves Soviet-trained engineers with confusion regarding their place in an American occupational hierarchy. Many hours of counseling, vocational assessment and job readiness training are needed to prime refugees for the job search experience.

The process of looking for a job is alien to Soviet refugees. In the Soviet Union, one gets a job upon completion of education or training and that is the job that is kept for life. Upward mobility or promotions are not concepts that are familiar to Soviet workers. Once again, reorientation for newly arrived refugees is vital. The process of searching for a job, including writing a resume and cover letter, scheduling interviews, preparing for interviews and contemplating and accepting a job offer, must be taught. For scientists and engineers interested in conducting research at a university, an orientation to collegiate conventions and practices are also important. They must learn what an academic calendar is so they can coordinate their job search efforts with a university's hiring schedule.

Perhaps the most striking and crucial barrier to employment is the lack of basic English language skills. Technical training is fundamental, but without the ability to communicate in English,

employment is unattainable. Beyond that, NYANA has found that often times employers are not comfortable hiring someone who looks or sounds "foreign." Whether this is due to sanctions under the Immigration Reform and Control Act (IRCA) which has led to widespread documented discrimination, or it is merely just a more blatant form of prejudice, we cannot be certain. What is clear however, is without job-relevant English, or as we call it, Vocational English-as-a-Second language training, none of NYANA's clients are able to secure employment.

For scientists and engineers, in particular, there is another obstacle to employment beyond the lack of English. The outcome of formal education received in the Soviet Union yields a degree that for all intents and purposes is the equivalent of a university-granted Bachelors degree in the United States. The practical, "hands-on" experience that many of NYANA's clients come with is usually based upon a technology that may be several years outdated. Computer programmers, for example, lack familiarity with American systems. Soviet training has provided them with an understanding of computer systems. However, they are unfamiliar with American software packages and sophisticated technology. Soviet engineers have little experience with designing computer-based models. Their experience has been with physical modelling. Consequently, these refugees are starting with disadvantages: they come from a world where their education and experience makes them well-respected. In the United States, their training does not give them the edge that they expected.

And finally, the state of the United States' economy serves as an obstacle to employment. Jobs for mathematicians, nuclear scientists and rocketry engineers are scarce. Often, many of these

jobs have citizenship requirements or security clearances associated with them that consequently eliminate refugees from consideration. Some jobs, such as geophysicists and geologists, while available in other parts of the country, are scarce or non-existent in the New York vicinity. The thought of relocating once again may not be appealing. Furthermore, when the economy is slow, buildings are not built, roads are not fixed, and universities do not hire that extra professor. Civil, mechanical, and electronic engineers will not find jobs. Research scientists will remain unemployed.

While all these obstacles may sound overwhelming to you and me, remember that these individuals have survived persecution and an arduous journey to this country. They are motivated, resilient and determined.

At NYANA, we provide special services to overcome these obstacles:

Firstly we provide vocational training that goes beyond just skills or technical instruction. These programs have several components: general English language, vocational English, and job search skills, all in addition to the technical training instruction. To meet the needs of our refugee engineers, NYANA has developed an Engineer Retraining Program to provide Soviet-trained engineers with knowledge of engineering occupational practices in the United States. As the numbers of arriving engineers burgeoned, we knew that we had to provide them with specifically tailored instruction. We designed a demonstration program that offered short-term, intensive re-training in five engineering specialties. Funding was initially secured from foundations and other

private sources. The program offers 72 hours of technical instruction which is conducted by bilingual instructors, Soviet engineers who have been in the United States for several years and who have been practicing and instructing in their specific engineering discipline. Courses are taught in English and the native language is used to clarify points and to explain difficult concepts. By using this instructional method, clients have the opportunity to learn the subject matter with its corresponding English vocabulary, as well as improve their general English language skills. Emphasis is placed on explaining the differences between American and Soviet engineering terminology and practices. For example, electrical coding systems in the United States are different from those in the Soviet Union; the design of air conditioning and heating pump systems are different. Instruction, therefore, is given with the goal of contrasting the systems and teaching the American terminology. Additionally, program participants receive 150 hours of vocational English and job skills instruction which includes an introduction to the capitalist economy, "networking" techniques, and preparing for an interview. The original program was funded to assist 96 engineers; we have now secured refugee social service funding from New York State to enroll 120 in this retraining effort and foundation funds to help retrain another 58 engineers.

Generally, job placement figures from NYANA's vocational training programs range between 85 and 100 percent of those enrolled. Placement into highly skilled and higher paying professions typically runs at 70 percent. Of those that have already completed the Engineer Retraining Program, 45 percent were employed as engineers one month after program completion. An additional 27 percent have either found other employment or continued other education or

training. NYANA's experience has indicated that it may take up to four months to place engineers in jobs upon training completion. Nonetheless, without training, it is improbable that many engineers could successfully gain employment in their chosen field.

Secondly, NYANA, in collaboration with the Committee of Concerned Scientists and the New York Academy of Sciences, has formed a Program for Refugee Scientists intended to help those who recently arrived to become integrated into the scientific life of the United States and to find employment in their chosen specialty. The Program is supported by grants from foundations. Like the Engineer Retraining Program, it is limited in scope and size. Recently arrived refugee scientists apply to the Program for selection as participants. Selection is made by a committee based upon professional credentials. Participants are required to secure a commitment from a university which allows them to use their university as a site for scientific research for a year's duration. There is no cost to the university. An award of \$1,000 to the participant is intended for miscellaneous expenses incurred while at the university related to the search for employment, such as telephone calls, resume preparation, or library fees. Travel to conferences or for interviews is also covered by the award. During the year's assignment, the scientists are pursuing research and a job search. Foundation funding enabled 25 individuals to be placed at universities throughout the country. Sixteen have already secured permanent employment at universities for this fall.

Thirdly, to serve these professionals, NYANA has established an Emigre Advisory Committee, known as the EAC. Composed of former clients who have successfully attained jobs, as well

as other professionals in the business world, the EAC provides liaison and networking connections for clients. Clients are referred to EAC members who hold jobs in the same field. They meet for informational interviews and EAC members advise clients as to how to secure positions in the field. Because former clients are serving on the Committee, they offer a dose of reality to current clients. Current clients hear details of pursuing a position from those that have preceded them. NYANA provides clients with many resources to facilitate their job search: access to typewriters and word processors so that resumes and cover letters may be prepared; access to telephones to arrange interviews; and a library of technical scientific documents in English and Russian.

NYANA has just recently augmented its advisory structures by establishing a Science and Technology Advisory Board. Members of the board include persons with training in the sciences or other technical fields who are willing to give time to assist clients in search of employment. They offer the same kind of service that the EAC does: they facilitate networking into the specific technical field offering technical assistance and advice. Only clients with the most outstanding credentials are referred to this program. Seminars are conducted on a weekly basis by the Chair of the Advisory Board to provide clients with job search skills and employment information. Resume and cover letter preparation is provided.

Finally, through the National Association of Jewish Vocational Service (NAJVS) organizations, NYANA is participating in the development and support of a national computerized data bank listing vacancies in science and technical fields. NAJVS affiliated agencies can access the data

bank to secure information about job openings throughout the country. This system has the capability to be replicated to other service provider networks.

Given NYANA's recent experience helping to place newly arrived Soviet scientists and engineers, I would like to offer the following recommendations to this Subcommittee:

Firstly, orientation is fundamental. Foreign-born individuals must be appraised of basic economic and cultural differences between the United States and the Soviet Union. Once that is understood, English, vocational English, and job search skills must be made a part of all initial job readiness exercises. These services require special funding; perhaps the Subcommittee can address the need for resources to help facilitate the transition of Soviet and other foreign-trained scientists and engineers into the American labor market.

Secondly, expanded training opportunities for engineers and scientists should be made available. Perhaps this requires rethinking of basic resettlement strategies at the national level. Additional federal funding of refugee-specific vocational training programs would serve to enhance the skills of those with professional and technical degrees who lack familiarity with American systems and the English language.

And lastly, on the employer side, potential employers must be made aware of the resource that is the foreign-trained professional. Their technology may be slightly outdated, and their English accented, but they are nonetheless a rich pool of workers available to fill vacancies in the

science professions. Perhaps, it is within the purview of this Subcommittee to publicly announce the findings of these hearings. Media coverage could emphasize to potential employers that a valuable pool of employees is available.

I am gratified to speak with you this afternoon and to discuss our experiences preparing newly arrived engineers and scientists with critical information as they begin their new lives here in the United States. I would now like to take this opportunity to ask Dr. Rafail Kushak to speak for a few moments. Dr. Kushak emigrated to the United States several months ago, and I believe his story can more poignantly demonstrate what a well-credentialed researcher must endure. Dr. Kushak....

Appendix A

Background Information on the
New York Association for New Americans, Inc.

The New York Association for New Americans was established in 1949, and is currently the largest voluntary, non-profit refugee resettlement agency in the United States. Accepting its clients by referral from the Hebrew Immigrant Aid Society (HIAS), NYANA has resettled approximately half of all Jewish refugees who have received permission to come to this country. At the request of the United States Department of State, NYANA has also provided resettlement services to refugees of other faiths from Southeast Asia, Afghanistan, Ethiopia and other parts of the world. NYANA's mission is to assist refugees to achieve self-sufficiency through employment and to facilitate their becoming socially integrated members of society as quickly as possible.

The agency's work began following World War II when thousands of displaced persons were fleeing the aftermath of the Holocaust and the devastation of Eastern Europe. Since then, NYANA has provided essential resettlement services to wave after wave of refugees who have come to New York seeking freedom: from Romania, Greece, Hungary and Egypt in the 1950's; from Cuba, Czechoslovakia and Poland in the 1960's; from the Soviet Union, Iran, Southeast

Asia, Afghanistan, Ethiopia and Syria in the 1970's and 1980's. Over 350,000 refugees from 39 different countries have been assisted by NYANA. The agency has been likened to an accordion, expanding in response to each major influx and contracting during intermittent periods of calm.

NYANA's job begins on the day that the refugee arrives in New York. Unique in combining complete initial resettlement services under one administration, the agency provides short-term financial aid, housing, referral for medical care and a comprehensive array of other resettlement services, including individual and family counseling, acculturation programs, English language training, vocational counseling and job placement, occupational skills training and recertification. NYANA receives a portion of its funding for basic resettlement services from the United States Departments of State and Health and Human Services.

The migration of Soviet Jewish refugees to New York City began in the 1970's, with a steadily increasing flow from less than 1,000 in 1972 to 12,200 arrivals in 1979. By the close of the decade 27,500 Soviet refugees had made New York their home. The picture in the 1980's was different. Immigration dropped precipitously from 6,500 arrivals in 1980 to 2,800 in 1981, with less than 1,800 Soviet Jews arriving during the five-year period from 1982 through 1986. Then we began to see the beginning of a thaw in U.S.-Soviet relations and the pay-off for our government's persistent advocacy for the freedom of Soviet Jews, as arrivals increased to 1,500 in 1987, jumped to 5,000 in 1988 and soared to 17,300 in 1989. Thus, nearly 35,000 Soviet Jews arrived in New York during the 1980's.

The 1990's have begun with a rising tide of anti-Semitism in the Soviet Union forcing many Soviet Jews to flee their country of origin. The United States government plans to admit 40,000 Soviet Jewish refugees in each of the next two years. This means that NYANA expects to resettle 18,000-20,000 Soviet refugees during 1990 in New York City and a similar number in 1991. If the 1990 and 1991 projections hold true, then New York will have welcomed 100,000 Soviet Jews since the 1970's. We estimate that New York City's Soviet Jewish population will double within five years and may reach 300,000 by the end of the decade.

Appendix B

Mr. Mark Handelman, ACSW
New York Association for New Americans (NYANA), Inc.
Biographical Sketch

Mark Handelman is the Executive Vice President of the New York Association for New Americans (NYANA), Inc., which is the largest refugee resettlement agency in the United States. In his ten years of service to NYANA, Mr. Handelman has elevated the agency to a prominent position within the Local, State and national refugee resettlement services delivery system.

In January 1989, Mr. Handelman was elected Chairman of the National Immigration, Refugee and Citizenship Forum. The Forum is the nation's major information clearinghouse for national and local groups that deal with immigration-related issues.

Mr. Handelman holds a Master's Degree in Social Work from Adelphi University. He has extensive knowledge of migration and resettlement service delivery systems. He possesses more than twenty five years of experience in the Human Services field (fifteen in Jewish Communal Services) as Administrator, Supervisor, Planner, Educator and Consultant. In addition to his many roles, Mr. Handelman currently serves as adjunct Professor of Social Work at Yeshiva University.

Mr. BROWN. All right. We are going to welcome Doctor Kushak and see how well he has managed in the last seven months.

Doctor Kushak, please proceed.

STATEMENT OF DR. RAFAIL KUSHAK, REFUGEE SCIENTIST

Dr. KUSHAK. Mr. Chairman and members of the subcommittee, my name is Doctor Rafail Kushak. I am a refugee who emigrated from the Baltic republic of Latvia in the Soviet Union four and a half months ago. I hold a Ph.D. in Biochemistry from the Latvian Academy of Sciences, and a second Ph.D. in Physiology from Lenin-grad's Institute of Evolutionary Physiology and Biochemistry.

My fields of interest are the biochemistry and physiology of digestion and nutrition, biological evaluation of different products such as food and pharmaceuticals, and the development of food additives and protein concentrates. I have authored two books, more than one hundred articles, and hold seven patents.

Through the efforts of HIAS and NYANA, my family and I have begun to establish a life here in the United States. Our departure from the Soviet Union began with a migration to Vienna, then Rome, and finally admittance into the United States. Our arrival in New York during March coincided with the arrival of many other refugees to be resettled by NYANA. NYANA provides us with services such as language training, career counseling, job placement services, housing search assistance, health care, and other.

All these services are very important for refugees, but for professionals, especially for scientists and engineers, no less important is the knowledge of how to look for a job. And in this field, NYANA gives us valuable help. Based upon my personal experiences, I would like to explain how NYANA has helped me.

For three weeks I attended NYANA's job skills courses where many refugees were trained on how to look for a job, conduct informational and job interviews, and prepare resumes and cover letters. At the same time, I took part in a seminar organized by NYANA's Science and Technology Advisory Board for scientists and highly qualified engineers. This seminar, lead by professional scientists, gave me additional information on searching for a job such as networking, conducting informational interviews, library research, negotiating with personnel management and hiring personnel, and other important things in the American system of employment. As a participant of this seminar, I also had access to typewriters, telephones, and different manuals and directories.

I believe that the skills that I got during this training program helped me to receive three job offers—from the Cornell University Medical School, from Hahnemann University in Philadelphia, and from the Children's Hospital in Boston. It is also significant that the first offer that I received was a networking contact made with the help of NYANA. I clearly understand that looking for a job is a hard business even for a person who is born in the United States and received American education. But it is especially difficult for a refugee who came from the Soviet Union where practices of searching for a job and hiring are quite different. Professionals in the

Soviet Union very seldom change their jobs, especially Jews, because it is very difficult for Jews to get a job.

The other obstacle for employment for refugees is the lack of English language skills. In the U.S.S.R. there are little contacts with non-Soviets. There is very limited international professional exchange with specialists so you could learn language mainly by yourself. I learned English by reading scientific magazines and books and listening to the radio. But I had no practice conducting a conversation. I know that I have to improve my English especially in grammar and sentence structure.

The process of searching for employment depends not only on job search skills, language knowledge, and the relationship with the hiring manager during the interview, but also on personal characteristics, flexibility, and ambitions. For some refugee scientists and engineers, it is difficult to forget the advanced degrees and high posts that they had in the U.S.S.R. They don't want to accept lower positions. Some refugees are looking for a job only in their narrow field.

You must not forget also that all refugees are in a state of psychological shock connected with emigration—changing their country, language, style of life, and environment. Many of us come here to escape persecution, often leaving behind us all that is familiar including occupational status, possessions, family, and friends. The most stressful are the first few months, so I think that the help that we received from NYANA during this most painful period of our lives is invaluable. It helps many of us to escape depression, frustration, and doubts in our decision.

At the same time, NYANA's activities allow us to offer the United States our high creative potential. After some period of adaptation, most scientists and engineers begin to work in their professional fields using all their knowledge and experience for the further development of their new homeland. I think that we are a valuable resource.

Using the opportunity of this presentation, I want to acknowledge the American Government, Jewish philanthropic organizations, and especially NYANA for their noble mission on the absorption of Russian refugees in the United States.

I am truly thankful to the members of the House for the possibility to speak before you about the difficulties and hopes of Russian scientists and engineers.

[The prepared statement of Dr. Kushak follows:]

Testimony by Dr. Rafail Kushak before the
House Committee on
Science, Space and Technology
Subcommittee on Science, Technology and Research
July 31, 1990

Chairman Valentine and members of the Subcommittee, Ladies and Gentlemen, my name is Dr. Rafail Kushak. I am a refugee who emigrated from the Baltic republic of Latvia in the Soviet Union four and a half months ago. I hold a Ph.D. in Biochemistry from the Latvian Academy of Sciences, and a second Ph.D. in Physiology from Leningrad's Institute of Evolutionary Physiology and Biochemistry.

My fields of interest are the Biochemistry and Physiology of Digestion and Nutrition, biological evaluation of different products such as food and pharmaceuticals, and the development of food additives and protein concentrates. I have authored two books, more than a hundred articles, and hold seven patents.

Through the efforts of HIAS and NYANA, my family and I have begun to establish a life here in the United States. Our departure from the Soviet Union began with a migration to Vienna, then Rome, and finally admittance into the United States. Our arrival in New York, during March, coincided with the entry of many other refugees to be resettled by NYANA. NYANA provides help with services such as language training, career counseling, job placement services, housing search assistance, and health care.

All these services are very important for refugees, but for professionals, especially scientists and engineers, no less important is the knowledge of how to look for a job. And in this field, NYANA gives us valuable help. Based upon my personal experiences, I would like to explain how NYANA has helped me.

For three weeks I attended NYANA's job skills courses where many refugees were trained on how to look for a job, conduct informational and job interviews, and prepare resumes and cover letters. At the same time, I took part in a seminar organized by NYANA's Science and Technology Advisory Board for scientists and highly qualified engineers. This seminar, lead by a professional scientist, gave me additional information on searching for a job such as networking, conducting informational interviews by telephone, doing library research, understanding the functions of agencies and job search firms, negotiating with personnel officers, hiring managers and many other very important things in the American system of employment. As a participant of this seminar, I also had access to typewriters, telephones, and assorted professional directories and manuals to help with my job search.

I believe that the skills that I got during this training program helped me to receive three job offers: from Cornell University Medical School, from Hahnemann University in Philadelphia and the Children's Hospital in Boston. It is also significant that I received these job offers through networking contacts made with the help of NYANA. I clearly understand that looking for a job is a hard business for every person even if he or she was born in the United States and received an American education. But it is especially difficult for a refugee who came from the Soviet

Union where the practices of searching for a job and hiring are quite different. Professionals in the Soviet Union change their work rather seldomly, especially Jews, because it is very difficult for Jews to get jobs. Even scientific research is not as difficult as the process of looking for a job in the United States. Here, it is not only what you know but whom you know.

For example, after graduating from the Latvian State University with honors, I started to work at the Institute of Biology Latvian Academy of Sciences. I worked in the same institute for twenty-six years until my departure from the USSR. I did not change my work because I was interested in my investigations, but also because I understood that it will be impossible to find another job in research.

The other obstacle to employment for refugees is the lack of English language skills. In the USSR there are little contacts with non-Soviets. There is no international professional exchange of information. So you could learn a foreign language only by yourself. I learned English by reading specialized scientific magazines and books, and listening to the radio. But I had no practice conducting a conversation. I know that I have to improve my English especially in grammar and sentence structure. It is necessary for communicating with Americans, writing papers, and presenting my research findings before my American colleagues.

The process of searching for employment depends not only on job search skills, language knowledge and the relationship with the hiring manager during the interview, but also on personal characteristics, flexibility, and ambition. For some refugee scientists it is difficult to forget the

advanced degrees and high posts that they had had in the USSR. They don't want to accept lower positions. Some refugees are looking for jobs only in their narrow field.

You must not forget also that all refugees are in a state of psychological shock connected with emigration -- changing their country, language, style of life, and environment. Many of us come here to escape persecution, often leaving behind all that is familiar including occupational status, possessions, family and friends. The most stressful are the first few months, so I think the help that we received from NYANA during this more painful period of our lives is invaluable. It helps many of us to escape depression, frustration and doubts in our decision.

At the same time, NYANA's activities allow us to offer the United States our high creative potential. After some period of adaptation most scientists and engineers begin to work in their professional fields using all their knowledge and experience for the further development of their new homeland. We are a valuable resource.

Using the opportunity of this presentation I want to acknowledge the American government, Jewish philanthropic organizations and especially NYANA for their noble mission on the absorption of Russian refugees in the United States.

I am truly thankful to the members of the House for the possibility to speak before you about the difficulties and hopes of Russian scientists and engineers. I have the same thoughts as other Russian professionals, who want to become valuable members of American society as quickly

as possible. Mr. Handelman and I welcome this opportunity to answer any questions.

Appendix

Dr. Rafail Kushak
Refugee Scientist
Biographical Sketch

Dr. Rafail Kushak is a Soviet-trained scientist who emigrated with his family to the United States in April 1990. He holds a Ph.D in Physiology from the Institute of Evolutionary Physiology and Biochemistry in Leningrad, and a second Ph.D in Biochemistry from the Latvian Academy of Sciences in Riga. He has written two books, published more than 100 articles, and holds seven patents. He received the Latvian Academy of Sciences' first prize for achievement in 1977 and in 1984.

Dr. Kushak is a scholar in the areas of biochemistry and the physiology of digestion and nutrition, as well as the biological evaluation of different products such as food and pharmaceuticals. He has also investigated the development of protein concentrates and the feeding of farm animals and fowl. Prior to leaving the Soviet Union, Dr. Kushak was Lead Scientist at the Institute of Biology, Latvian Academy of Sciences in Riga where under his direction, a team of biologists developed protein concentrates for human and animal nutrition and their biological evaluation.

Mr. SKAGGS [ASSUMING CHAIR]. Thank you very much for your testimony, Doctor. I am sorry I arrived in the middle of it, but it was very helpful to get a kind of personal insight into the experience that you and others who have emigrated especially from Eastern Europe are likely to be facing in this country.

Let me call on my colleague from Maryland, Ms. Morella, for questions.

Mrs. MORELLA. I just want to thank you both for coming. I learned something about NYANA and I learned—Doctor Kushak, I don't know what your sentence structure is like, but I certainly think that your English is excellent. I am very, very impressed with—

Mr. SKAGGS. Here, here.

Mrs. MORELLA. Right. Pronunciation and all. I say that as a former English teacher, as a matter of fact. It appears as though this is a tribute to NYANA for what you have done. I have worked a lot with some of the former "refuseniks" in my area of representation, which is metropolitan Washington, and I can understand some of what you say with regard to some of the enormous obstacles that they are facing, not only in terms of the language problem, which is a major one, but in terms of assimilating within the cultural, and in terms of religion, too, as a matter of fact, some of those enormous problems.

I guess I would ask both of you what you think we should do as Members of Congress. I know you offered in your testimony, Mr. Handelman, some suggestions. But recognizing all of this, what more can we do; if there is any advice you would like to give us? I want to congratulate you on what you have been doing with NYANA.

Mr. HANDELMAN. Thank you. I think that the most significant recommendation that we could make is to somehow address the need for more resources that could be used to provide training programs for newly arrived emigre professionals. I not only include engineers and scientists, but refer, for example, to the hundreds of emigre physicians who have come into this country and who have, in many cases, been able to pass the ECFMG and FLEX recertification exams but cannot find hospital-based residencies and, therefore, have to be retrained and, in many cases, in the allied health fields which are demand occupations. Training monies are scarce but training is really the key.

A number of years ago NYANA, in conjunction with the Cooper Union School of Engineering, retrained almost 60 Soviet emigre engineers who had specialties that were not in demand in piping design engineering which, at the time, was in much demand in the oil industry. We were able to place all of those engineers in very, very lucrative positions around the country.

The backgrounds that the Soviet-trained engineer and scientist bring are very solid, but there is a need for updating their knowledge of technology and giving them a perspective on the specialties that are in demand in the United States, and that can only be done through further provision of training funds.

Mrs. MORELLA. Does the private sector help in that way? It seems to me they could gain if they also helped to establish programs of that nature.

Mr. HANDELMAN. They do. In fact, one of our strategies is to approach business and industry and suggest that we are not asking for favors from them in terms of their consideration of our clients as potential employees, but that in fact we can provide skilled labor to meet their needs through training approaches which they have often been interested in helping to subsidize. But I must tell you that it doesn't work always and it doesn't work for every particular profession. Through such vehicles as the Job Training Partnership Act, we have been able to create refugee-specific training programs that definitely meet the need, and we would encourage further funding of those types of programs.

Mrs. MORELLA. Does the National Science Foundation have any involvement with what you are doing?

Mr. HANDELMAN. Yes. We have tapped a variety of governmental resources; I mentioned the State of New York, the Federal Office of Bilingual Vocational Education, where we did a training course bilingually with a grant. Wherever we can we try to get both private and public sector support. But I cannot stress enough how valuable even short-term training, refresher courses, are for engineers and scientists, and then they can speedily move into employment in the United States.

Mrs. MORELLA. Doctor Kushak, have you been assisting other refugees who have been coming in?

Dr. KUSHAK. I want only to add that I agree with all of what was said by Mr. Handelman. I think it is very important also for refugees to have information about the job openings not only in the city where they are living but in other places throughout the United States.

Mrs. MORELLA. So a clearinghouse would be very, very helpful.

Dr. KUSHAK. Yes. Information, new information about the job opportunities.

Mrs. MORELLA. Okay. Doctor Kushak, the really big question, what is going to happen with Lithuania? Are you speculating in any way?

Dr. KUSHAK. No. I am interested very much about the fate of Lithuania and other Baltic republics because I—

Mrs. MORELLA. Are you from Lithuania or Latvia?

Dr. KUSHAK. No, I am from Latvia. But it has approximately the same situation. I hope that if no more hard tensions about racists that sooner or later Lithuania will succeed in independence. I hope so.

Mrs. MORELLA. We thank you both for coming today. I appreciated hearing your testimony.

Thank you, Mr. Chairman.

Mr. SKAGGS. I wanted to raise a question with you, Doctor Kushak, that one of our colleagues raised earlier this morning, and that is do you expect the liberalization of the Eastern European countries—and we hope the Soviet Union—to have an affect on the incentive that has existed until currently for persons such as yourself to want to emigrate? Will some of the incentive be removed as greater freedoms and abilities to determine careers of choice are made available to the people of these countries?

Dr. KUSHAK. I think that liberalization takes place in the Soviet Union now and that the fact that I am here is a result of this liber-

alization because a year or two ago I couldn't imagine that I would receive permission to go abroad.

Mr. SKAGGS. But looking two or three years ahead and painting the hopeful picture of economic restructuring having started to succeed, a sense of better opportunity and freer societies at home, would you suspect that fewer of your countrymen would decide to leave and would, instead, decide to stick it out and pursue their science or engineering careers in their native lands?

Dr. KUSHAK. I think that it will depend upon the situation in the country. If the situation will be normal, it will be not any tensions, no civil war, then I think that is possible.

Mr. SKAGGS. Mr. Handelman, I am curious also how people learn about your program and also your sense of the underemployment that persists—obviously, not for people that have been your clients, but those that aren't fortunate enough to get your kinds of services—how much talent are we wasting in the emigrant technical population in this country?

Mr. HANDELMAN. Our agency specifically resettles refugees and, of course, that system is a very defined one and we accept refugee cases while they are still overseas so that people don't have to find out about us; we are kind of a given when they arrive and we are working with them from the minute they hit the ground at Kennedy.

But in terms of your question related to the general emigrant population, of which refugees are a small but significant part, I think that we have a tremendous amount of talent that could be capitalized on, again, if we were able to offer an expansion of the kind of approach that we have been able to develop at NYANA specifically for the Soviet refugee population. The networking approach—and I think that has been confirmed by Doctor Kushak—is absolutely essential, and a use of people who have, in fact, preceded the people who are now coming and who have made the connections and who can open the doors is invaluable because, especially in the areas of engineering and science, you don't get a job through the New York Times. It really depends upon knowing about the opening and having a kind of connection and sharing that kind of influence with the newcomer. And that is what we have been able to do and an expansion of that type of approach I think is essential. The advertising of jobs through a variety of means, including networking, the computerized data bank approach that we are trying to implement now, all are going to be very helpful.

But I do believe that, as I said before, many of the people come with a very, very solid educational background, good experience, but it is not American experience and that is held against them. It is kind of a Catch 22. Emigrant professionals come in, they are told that they need American experience in order to be hired, they can't get American experience because they can't be hired because they don't have American experience. And so devices must be developed by which we can somehow entice industry into trying an experimental approach, perhaps through such techniques as on-the-job training or supported work where job counselors, for example, are provided along with the potential employees to handle potential problems in communication, for example, and language difficulties in the early weeks of employment. But there is definitely a

need to address the issue of a resistance on the part of American industry to really tap into what I think is a very rich and talented pool of potential employees.

Mr. SKAGGS. How do you get your funding?

Mr. HANDELMAN. Through private funds and through the per capita grants made available for refugee resettlement from the Federal Government.

Mr. SKAGGS. And are there comparable organizations to yours elsewhere in the country?

Mr. HANDELMAN. There are affiliates of other national resettlement operations around the country that do similar work. Our particular model of resettlement is somewhat unique in the sense that all of the services that we provide are administered under one roof, so to speak, and we have a very extensive and a very highly integrated service delivery system as a result. I would also guess, as I said, that we are dealing in the kind of volume that very few other organizations deal in. This year we have resettled 20,000 refugees, primarily from the Soviet Union but also from Iran and Syria and IndoChina, in the New York area.

Mr. SKAGGS. I just want to chime in with Mrs. Morella, Doctor Kushak, you are being far too modest about your literacy in English based upon your presentation this morning; either that or NYANA has done a remarkable job in four and a half months of language work. I am sitting here speculating if you have done so well in that brief period of time and are testifying before us less than six months after you have arrived, I don't know whose congressional district you live in but they ought to be aware that this kind of fast progress is putting us all on notice.

We wish you the very, very best in your career and we welcome you. I am proud to have a legislative assistant who is second generation Latvian, so I get a little bit of in depth coverage of your particular Nation's needs and culture in my office. We wish you very much the best.

Dr. KUSHAK. Thank you.

Mr. SKAGGS. Mrs. Morella, anything further? _

Mrs. MORELLA. No, Mr. Chairman.

Mr. SKAGGS. Thank you again for coming this morning.

The hearing is adjourned.

[Whereupon, at 12:19 p.m., the subcommittee was adjourned, to reconvene at the call of the Chair.]